THE EFFECT OF INSTRUCTION WITH CONCRETE MATERIALS ON FOURTH GRADE STUDENTS' GEOMETRY ACHIEVEMENT

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

SİBEL SARI

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
SECONDARY SCIENCE AND MATHEMATICS EDUCATION

FEBRUARY 2010

Approval of the Thesis:

THE EFFECT OF INSTRUCTION WITH CONCRETE MATERIALS ON FOURTH GRADE STUDENTS' GEOMETRY ACHIEVEMENT

submitted by **SİBEL SARI** in partial fulfillment of the requirements for the degree of **Master of Science in Secondary Science and Mathematics Education, Middle East Tachnical University** by,

Prof. Dr. Canan Özgen ________________
Dean, Graduate School of **Natural and Applied Sciences**

Prof. Dr. Ömer Geban ________________
Head of Departmant, Secondary Science and Mathematics Education

Assoc. Prof. Dr. Safure Bulut ________________
Supervisor, Secondary Science and Mathematics Education

Examining Committe Members:

Prof. Dr. Ömer Geban
Secondary Science and Mathematics Education Dept., METU, ________________

Assoc. Prof. Dr. Safure Bulut
Secondary Science and Mathematics Education Dept., METU, ________________

Prof. Dr. Sinan Olkun
Elementary Education Dept., Ankara UNIV., ________________

Assoc. Prof. Dr. Erdinç Çakıroğlu
Elementary Education Dept., METU ________________

Dr. Cengiz Savaş Aşkun
Computer Education and Instructional Technology, METU ________________

Date: 04.02.2010

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name: Sibel Sarı

Signature:

ABSTRACT

THE EFFECT OF INSTRUCTION WITH CONCRETE MATERIALS ON FOURTH
GRADE STUDENTS' GEOMETRY ACHIEVEMENT

Sarı, Sibel

M.Sc., Department of Secondary Science and Mathematics Education

Supervisor: Assoc. Prof. Dr. Safure Bulut

February 2010, 130 pages

The primary purpose of this study was to investigate the effectiveness of concrete materials on fourth grade students' geometry achievement. The secondary purpose was to investigate their opinions and feelings about instruction with concrete materials. The study was carried out in a private school in Ankara with 32 fourth grade elementary school students. One group pretest-posttest design was used. Geometry Achievement Test was administered to collect the necessary data. The instruction with concrete materials was applied by the researcher five hours per week in 10 weeks. The data were analyzed by using one-way repeated measures analysis of variance. Also, an interview was conducted with 11 students to determine their opinions and feelings about instruction with concrete materials.

The results of the study revealed that there was a statistically significant change in geometry achievement of fourth grade students who participated in the instruction with concrete materials over three time periods. In other words, there were statistically significant positive changes in students' geometry achievement across pre-intervention and post-intervention and across pre-intervention and follow-up. Moreover, there was no statistically significant change in students' achievement across post-intervention and follow-up. The other results can be deducted from the study: most of the students enjoyed the class more when concrete materials were used; some of the students became anxious when they first saw the questions in pre-intervention; most of the students stated that questions become easier after instruction with concrete materials; cubes and the geoboard were the most useful and most liked as perceived by the students.

Keywords: Concrete materials, geometry achievement, feelings, opinions, fourth grade students.

ÖZ

SOMUT MATERYALLERLE ÖĞRETİMİN DÖRDÜNCÜ SINIF ÖĞRENCİLERİNİN
GEOMETRİ BAŞARISINA ETKİSİ

Sarı, Sibel

Yüksek Lisans, Orta Öğretim Fen ve Matematik Alanları Eğitimi Bölümü

Tez Danışmanı: Doç. Dr. Safure Bulut

Şubat 2010, 130 sayfa

İlk amacı somut materyallerle öğretimin 4. sınıf öğrencilerinin geometri başarısına etkisini araştırmaktır. İkincil amacı ise, öğrencilerin somut materyaller ile yapılan dersler ile ilgili duygu ve düşüncelerini araştırmaktır. Ankara'da bulunan bir özel okulda, 32 tane 4. sınıf öğrencisiyle yapılan bu araştırmada bir gruplu ön test – son test araştırma deseni kullanılmıştır. Verileri toplamak için Geometri Başarı Testi uygulanmıştır. Somut materyallerle yapılan öğretimin, 10 hafta süresince haftada 5 ders saati olmak üzere araştırmacı tarafından yapılmıştır. Veriler, tek yönlü tekrarlı varyans analiz kulanılarak analiz edilmiştir. Ayrıca, 11 öğrenci ile görüşme yapılarak, öğrencilerin somut materyaller ile yapılan dersler ile ilgili duygu ve düşünceleri araştırıldı.

Bu çalışma, somut materyaller ile yapılan öğretimin, 4. sınıf öğrencilerinin 3 zamanlı periyotta geometri başarısında istatistiksel olarak anlamlı bir değişim olduğunu göstermektedir. Bir başka deyişle, öğrencilerin uygulama öncesi ve hemen sonrası ile uygulama öncesi ve belirli bir zaman sonrası geometri başarıları arasında olumlu yönde bir değişim olduğu saptanmıştır. Ayrıca, bu çalışmanın sonucunda öğrencilerin, uygulamanın hemen sonrası ve belirli bir zaman sonrası geometri başarıları arasında istatistiksel olarak anlamlı bir değişim olmadığı sonucuna varılmıştır. Bu çalışmadan çıkartılabilecek diğer sonuçlar ise; öğrencilerin çoğu somut materyaller ile yapılan dersleri daha eğlenceli bulmuştur, bazı öğrenciler, sorular ile ilk karşılatıklarında endişe duymuşlardır; öğrencilerin çoğu ise sorular ile somut materyallerle yapılan öğretim sonrası karşılaştıklarında soruları daha kolay bulmuşlardır; öğrencilerin en çok sevdiği ve yararlı bulduğu materyaller ise küpler ve geometri tahtası olmuştur

Anahtar Kelimeler: Somut materyaller, geometri başarısı, duygular, düşünceler, dördüncü sınıf öğrencileri.

To my husband

Orkan Okumuş

ACKNOWLEDGMENTS

I would like to thank to my supervisor Assoc. Prof. Dr. Safure Bulut for her valuable guidance and help throughout the study.

I am grateful to my husband who does not leave me alone in this way. Also, my appreciation goes to my mother, Emine Sarı and my father, Selahattin Sarı who provided valuable support throughout my education and my life.

TABLE OF CONTENTS

LIST OF TABLES

TABLES

LIST OF FIGURES

FIGURES

LIST OF ABBREVIATIONS

GAT: Geometry Achievement Test

ICM: Instruction with Concrete Materials

MONE: Turkish Ministry of National Education

NCTM: National Council of Teachers of Mathematics

Flw: Follow-up

ANOVA: Analysis of Variance

SPSS: Statistical Packages for Social Science

M: Mean

SD: Standard Deviation

p: Probability

CHAPTER 1

INTRODUCTION

In all components of mathematics, geometry holds an important position in the sense that it helps students understand facts about the world they live in (Erdogan, Akkaya & Akkaya, 2009). Geometry is said to help students to better understand the world they live in because there exist shapes and objects in the context of geometry (Goos & Spencer, 2003; Pesen, 2003). One of the main goals of geometry education is to improve students' visual awareness and logical thinking ability (Tapan & Arslan, 2009). Other goals and objectives of geometry education can be summarized as using geometry within the process of problem solving, understanding and explaining the physical world around the students (Baki, 2001). However, traditional methods used in most of the mathematics classes do not allow students enough time to fully reach that understanding (Bayram, 2004). Various studies have documented that many students have difficulties in geometry (Fuys, Geddes, & Tischler, 1988; Gutierrez, Jaime, & Fortuny, 1991; Salaam, 2006). According to Hartshorn and Boren (1990), one way to strengthen students' understanding of geometry is the use of manipulatives. Similarly, Schweinle, Meyer, and Turner (2006) argued that the important factors that affect students' achievement toward geometry were students' experiences in the classroom. In addition, Ross (2004) stated that if students were actively involved in their own learning, understanding would come easily. Through the use of materials, students had a chance to touch, manipulate, and construct their own meaning and understanding (Ross, 2004). Likewise Ross (2004), a study which was conducted by Moch (2001) summarized that students have an opportunity to touch and feel mathematics by using manipulatives. It has also been argued whether manipulatives have an impact on the increase of academic achievement (Allen, 2007; Post, 1981).

Piaget (1973), Bruner (1966) and Van Hieles (1958) developed the strongest arguments in favor of concrete materials. By supporting them many studies were conducted to show the importance of the use of concrete materials at different grades (Dienes, 1971; Reys, 1971; Suydam and Higins, 1976; National Council of Teachers of Mathematics, 1989; Sowell, 1989; Allen, 2007; McClung, 1998; Thompson, 1994; Moyer 2001). Piaget (1973) studied the stages of cognitive development of children from birth to maturity. Piaget's theory identifies four developmental stages (Sensorimotor stage, preoperational stage, concrete operations and formal operations) and the processes by which children progress through them. According to Piaget's theory, this is a continuous process and the development of the next stage depends on completion of previous stages.

As Piaget summarised that the concrete operational stage is the basis for the use of manipulatives, fourth grade students who are in this stage were selected as a participant of this study. Both Piaget (1973) and Dienes (1971) were concerned with providing active student involvement with the use of huge amount of concrete material in the learning process.

Bruner's studies support Piaget's findings. Bruner (1966) described three ways of knowing: enactive, iconic, and symbolic. He stated that by touching, smelling, and tasting, people experiences the characteristics of the objects. Later, the child develops mental images and remembers the objects. Even later he/she connects names with the objects. According to Bruner, after children learn to distinguish objects by color, size, and shape they begin counting numbers. Similarly when the children start school, their education needs to start from concrete to move to abstract. Manipulatives can assist in this transition from concrete to abstract (Howden, 1986; Thompson, 1994; Moyer, 2001; McClung, 1998; Suydam & Higgins, 1976). Brown (2006) claimed that manipulatives were very important tools to make the connection from abstract to concrete understanding in everyday situations. Likewise, Thompson (1994) stated that to maximize the effects of concrete materials, the teachers must first realize what their students need to understand. Teachers had a big responsibility to make sure the students make the connections between the concrete materials and the abstract manipulations (Strom, 2009). According to Bayram (2004), the role of the teacher is to provide activities involving many concrete experiences to help students make this transition. According to Szendrei (1996), educational materials were not miracle drugs; their productive use requires planning and foresight. Also he noted that if teachers did not know the proper use of the materials, such materials might do more harm than good. Erdogan et al. (2009) stated that new teaching styles should be developed with using materials.

Some research was conducted in Turkey taking Van Hiele model as the basis (Erdoğan, 2006; Olkun, & Toluk, 2003). The most important feature of the Van Hiele model is that it explains the development of geometric thinking with five related levels. The Van Hieles' (1989) levels range from concrete structure (level 0) to visual geometric structure (levels 1-2) and then to abstract structure (levels 3-4). According to Van Hieles just like the Piaget's research, the learner cannot achieve a higher level of thinking without having passed through the previous level. Instructional experiences at each level are essential for effective progress. It is believed that development through Van Hiele's levels is more dependent on instruction (Koehler & Grouws, 1992).

To facilitate the use of manipulatives in today's Turkish curriculum, various activities are introduced in this study. As such, a primary goal of this study is to create awereness for the effects of using concrete models in geometry teaching/learning, and then familiarizing the teachers with the effective usage of concrete models. When the new elementary school mathematics curriculum is investigated, it is easily realized that the MoNE (2006) emphasizes on meaningful understanding and engaging students in examining, measuring, comparing, and contrasting a wide variety of concrete materials. So, in the present study it was investigated the effects of the instruction with concrete materials on students' geometry achievement. Moreover, the necessary activites for this instruction were developed by taking to consideration the theories and the research studies mentioned in this study.

Another important issue is related to students' attitude toward subject and instruction (Bloom, 1976). Some researchers investigated the effects of concrete materials on students' attitude toward mathematics (Allen, 2007; Battle, 2007;

Garrity, 1998). Battle (2007) stated that manipulatives could be used as a motivation and as a learning tool for success. Likewise, Allen (2007) and Garrity (1998) stated that manipulatives were the way to entertain students while they were learning mathematical concepts. In MoNE (2006) it was stated that teachers should be taken into account the development or improvement of students' positive affective characteristics related to mathematics and instruction. At this point of view, this study aims to investigate students' opinions and feelings about instruction with concrete materials.

1.1 Purposes of the Study

One of the purposes of the study is to determine if using geometrical manipulatives in 4^{th} grade students will increase students' geometry achievement. The important factors that affect students' achievement toward mathematics were students' experiences in the classroom. During this study it was aimed to create an opportunity for students to touch and feel mathematics by using manipulatives. Also, this study specifically focused on allowing students to manipulate objects to gain a deep understanding of geometry concepts.

Another purpose of the study is to investigate students' opinions and feelings about instruction with concrete materials.

1.2. Main and Sub-Problems of the Study and Associated Hypotheses

This section presents the main problem and related sub-problems of the thesis, and examines relevant hypotheses.

1.2.1. Main and Sub-problems of the Study

The first main problem was stated as below;

P.1. What is the effect of instruction with concrete materials on fourth grade students' geometry achievement?

The second main problem was stated as below;

P.2. What are the fourth grade students' opinions and feelings about instruction with concrete materials?

1.2.2. Hypotheses of the First Main Problem in the Present Study

Before studying the main problems, the following hypothesis of the first main problems was stated:

Hypothesis: There is no statistically significant change in 4^{th} grade students' geometry achievement across three time periods (pre-intervention, post-intervention, and follow-up).

1.3 Definitions of Terms

In this section, some of the terms used in this study are defined to prevent any misunderstandings.

1. *Concrete materials* refers the tools, which are constructed for educational purposes (geoboards, cubes, mason ruler etc.), and real life objects (pipes, toothpicks, sticky tape etc.).
2. *Instruction with concrete materials* refers to the instruction in which concrete materials were used as a learning tool. In order to teach students geometry effectively, activities were done by utilizing the concrete materials.

3. *Geometry achievement* refers to students scores obtained from geometry achievement test (GAT).
4. *Treatment* refers to the method of instruction with concrete materials (ICM).

1.4. Significance of the Study

Even though significant importance has been given to geometry and its education, it has been shown by many researches that the students' level of understanding geometry is below what is desired or expected of them (Burger & Shaugnessy, 1986; Clements & Battissa, 1992; Mitchelmore, 1997; NCTM, 1989; Prescott, Mitchelmore, & White, 2002). According to the TIMSS result, Turkey was in the last five among the 38 participant countries (Mullis, Martin, Gonzales, Gregory, Garden, O'Connor, Chrostowski&Smith, 2000). Likewise, PISA (2003) has shown that Turkish students' performed below the international average (Berberoglu, Celebi, Ozdemir, Uysal, & Yayan, 2003; TIMSS, 1999). Similarly according to the General Directorate of Education Technologies in MONE (2009), the OKS which is one of the large scales of national exam was necessary until 2008 for eighth grade students to enter some successful high schools throughout Turkey results in Turkey for the last three years were very low. An average of 3.7 was achieved out of 25 questions in 2008. It is not different for 2006 and 2007, the average scores of these years are1.7 and 3.35 respectively out of 25 questions. Another large scale of national exam was ÖSS and 2004 ÖSS results show that there are 32 177 students had a score of zero (Altun & Çakan, 2008). These results show that there need to be an important change in education system in Turkey.

In order to increase educational standards, some development and improvement efforts have been attempted in Turkish education system. It was necessary to develop new type of activities in which concrete learning environment was constructed and consistency occurs with the new curriculum. The present study gives different types of geometry activities by using concrete materials to 4^{th} grade mathematics teachers to assist orienting teachers to the new curriculum.

Also, in Turkey, there is an insufficient amount of research that has been investigated the effects of concrete materials in any grade in mathematics (Olkun &Toluk, 2004; Bayram, 2004; Bayrak, 2008). Yıldız (2004) has recently studied perceptions, beliefs, and expectations of the preservice teachers regarding the use of manipulatives in mathematics classes as well as the influence of the field experience on the use of manipulatives. Moreover, Cakıroglu and Yıldız (2007) studied on pre-service teachers' views about manipulative use in mathematics teaching.

On the other hand, there are lots of international researches that examined the effects of concrete materials into mathematics education (Dienes, 1971; Reys, 1971; Suydam and Higgins, 1977; National Council of Teachers of Mathematics, 1989; Sowell, 1989; Allen, 2007; McClung, 1998; Thompson, 1994; Moyer 2001). Szendrei (1996) argued that there are increasingly powerful methods for evaluating the effectiveness of concrete materials for mathematics instruction, but there are still many blank spots on the map of research in this area. So, there is need to perform such researches in Turkey and in other countries.

CHAPTER 2

REVIEW OF LITERATURE

In this chapter, the theoretical background for the instructional methods used in the present study is explained and the literature related to the present study is reviewed.

2.1 Theoretical Background

In this section, “Piaget’s Cognitive Development Theory”, “Bruner’s Theory of Instruction” and “The Van Hiele Model of Thinking in Geometry” was explained.

2.1.1 Piaget’s Cognitive Development Theory

Piaget (1973) studied the stages of cognitive development of children from birth to maturity. He believed that people go through four stages of development in understanding the world. Also, the studies of Piaget have provided the ways to educators about teaching mathematical concepts. As Sprinthall and Sprinthall (1977) stated that Piaget’s four stages must be taken into consideration before deciding on “what to teach” and “how to teach”. In this study, these stages are also taken into consideration.

Piaget’s stages of learning cover a child’s development from play to purposeful play to understanding and practice (Strom, 2009). Each of the stages is age-related and consists of distinct ways of thinking. McClung (1998) summarized the four stages of Piagetian development in Table 1.

Table 2.1 Descriptions of Piaget's Stages of Learning

Stage	Approximate Age	Major Characteristics
Sensorimotor	Birth- Two years	Motoric intelligence. No language thought, notion of objective reality at initial stage.
Preoperatioanal	Two – Seven Years	Egocentric thought. Reason dominated by perception. Intuitive rather than logical solutions.
Concrete Operations	Seven – Twelve Years	Logic of classes and relations. Understanding of numbers. Thinking concrete.
Formal Operations	Twelve Years - Adult	Complete generality of thought. Ability to deal with the hypothetical.

At *sensorimotor stage*, interaction between the senses of the children and the environment starts to take place (Sprinthall & Sprinthall, 1977). Children see and feel what is happening, but they have no way of categorizing their experience. Piaget (1977) stated that an additional characteristic of children at this stage is developing the connection of numbers with objects (e.g., one dog, two cats, three pigs, four hippos). According to Ojose (2008) educators need to provide activities that incorporate counting and thus enrich children's conceptual development of number. The quantity and the quality of experience gained from the activities during this stage prepare the child to move to the next stage.

At *preoperational stage*, objects and events begin to assume symbolic meaning. The characteristics of this stage include an increase in language ability.

Ojose (2008) argued that in this second stage, children should engage with problem-solving tasks that incorporate materials. In addition, children's capacity to store images improves; and children begin to display an increased ability to learn more complex concepts using their experiences provided that they are presented with familiar examples that have properties common to the ones that were explored at the previous stage (Sprinthall & Sprinthall, 1977). The child can not usually perform reverse operations in this stage such as they can add two numbers but can not make subtraction.

The *concrete operations* stage is characterized by cognitive growth. The two logical operations; seriation and classification develop during this stage (Piaget, 1977). Ojose (2008) explained these logical operations as seriation being the ability to order objects according to increasing or decreasing length, weight, or volume; and classification meaning the grouping of objects according to their common characteristics.

According to Burns and Silbey (2000), "hands-on experiences and multiple ways of representing a mathematical solution can be ways of fostering the development of this cognitive stage" (p. 55). The importance of hands-on activities is stressed during this stage. These activities assist to construct a bridge between the concrete and the abstract. Since concrete experiences are needed to form this bridge, manipulatives can be used to explore the topics and concepts. Another advantage of using materials during this stage is the development of the students' mathematical confidence (Ojose, 2008).

The concrete operational stage is the basis for the use of manipulatives, so children must be allowed to manipulate objects, try different experiments, pose questions, and test their findings against the perceptions of other children (McClung, 1998). An important tool for cognitive development in this stage is showing the children different ways for solving the problems as done in this study. Eggen and Kauchak (2000) noted that while a specific way of representing an idea is meaningful to some students, a different representation might be more meaningful to others.

During *formal operations* stage, the child starts to develop full formal patterns of thinking and abstract thought. In order to enhance students' understandings, games and simulations can be presented, so that the students would have an active role in teaching environment (Sprinthall & Sprinthall, 1977). The more active the symbolic process is, the more it improves cognitive growth.

In understanding the four stages of Piagetian development, it is very important to know that the child must go through each of the stages in a regular sequence and it is not possible to skip or bypass a stage. Children need to have enough experience at each stage and enough time to internalize this experience before they can move on to the next stage.

According to Piaget (1973), the main point in cognitive growth is that children's ideas about shapes do not originate from passive looking, instead they are formed as children's bodies, hands, eyes and the mind engage in action. Obviously, it was then argued that in order to increase the students' understandings about shapes, they should be given chances to explore them. Piaget (1973) provided many examples where the understanding can not be explained by motor ability, such as a child who could draw a pine tree with branches at right angles but could not draw a square with right angles. So, it was concluded that children need far more than a visual "picture". In short, action and exploration are inevitable during the learning process.

In general, Piaget argued that it was a waste of time to teach children things that they could not experience through their senses, thus concluding that the children must be allowed to manipulate objects (McClung, 1998). Also, a basic Piagetian concept denotes the importance of activity as a central ingredient of intelligence. According to Sprinthall and Sprinthall, active learning experiences tend to promote cognitive growth while passive experiences tend to have minimal effects. From this point of view in this study, it was underlined that students who the active role of student in a class

Piaget concluded that activity should be a major feature of classroom learning. In the light of this conclusion, during the exacution of this study it was expected from students to become very active in classes by using concrete materials. Moreover, Piaget noted that mathematics involves actions and operations, therefore understanding mathematics should begin with action. Piaget suggested that this process should start with concrete exercises. Likewise, in this study being active is very important while using concrete materials.

The students participated in this study are in "Concrete Operational Stage" of Piaget's learning stages. Many activities with manipulatives were done in this study to help students to translate the abstractions in geometry into concrete as Piaget emphasized. Piaget also stated that students in the concrete operational stage develop their own way of understanding the subjects. In order to achieve this, many ways of teaching methods should be shown by teachers. This way, the present study gives alternative way of teaching the subjects with concrete materials.

As a summary, Piaget (1973) noted that mathematics involves actions and operations; therefore, understanding mathematics should start with action. He also suggested that this process should start with concrete exercises. As Piaget stated that instructions should be given by doing experimental procedures and free activity, in the present study ICM was totally given by making students active.

2.1.2. Bruner's Theory of Instruction

Jerome Bruner developed a theory of instruction rather than a learning theory. Bruner's theory had four major principles: motivation, structure, sequence and reinforcement. Bruner (1966) argued that meaningful learning requires the child to actively search for solutions and good teaching relied on exploring alternatives and discovering new relationships.

According to the first principle, curiosity and competence are the inherent motivations that all children have as they are born into this world. "Children become interested in what they are good at and it is impossible to motivate them to engage in activities in which they have no degree of competence" (Sprinthall & Sprinthall, 1987, p.311). In this study, at the beginning of the activities, students' competence was taken into consideration.

Bruner’s second principle is “Structure”. According to this principle, if a subject or a problem is presented simply enough, any learner could understand the subject presented, thus concluding that learning which is based on structure is more lasting, having a higher chance of being permanent.

The third principle is “Sequence”. It was stated that sequence is a significant aspect of motivation. According to Bruner (1966), teaching involves leading the learner through a certain sequence of the various aspects of the subject. Initially, a new subject can be introduced with wordless messages. Then, students should be given chances to use diagrams and different pictorial representations to facilitate exploration of the subject. Lastly, the teacher should communicate messages symbolically through words, numbers and other symbols. The principle of sequence also stated that if a student finds a subject difficult, it depends on the sequence of the presented material.

The fourth principle is “reinforcement”. Bruner (1966) stated that students must receive feedback in order to solve a problem. The timing of this reinforcement is crucial to success in learning, and the reinforcement must be understandable. The time that the reinforcements are given is also important. If the reinforcement is given too early, it may discourage exploration; and if the reinforcement is delayed, the learner might have already incorporated false information at which time the effect of the reinforcement could be reduced or altogether negated.

Bruner’ theory of instruction was taken into consideration during this study. Similar with Bruner, the sequence for which the topics are instructed was important in this study. Moreover, the instructions were given according to the Bruner’s four major principles of theory of instruction.

As a summary Bruner (1966) stated that learning starts with the structure of knowledge, and therefore the final goal of teaching is to increase the understanding of the structure of a subject matter. So, teachers should try to provide conditions in which students can perceive the structure of subject matters easily. In the present study such a condition was formed by using concrete materials during instruction.

2.1.3 The Van Hiele Model of Thinking in Geometry

Geometry should be taught from easy to hard (Durmus, Toluk &Olkun, 2002). This idea is also presented in the Van Hiele model, where an instructional plan composed of five steps was formed in order to provide a transition from one level to another in students' geometry thinking (Olkun & Toluk, 2003). Van Hiele (1999) stated that in order to close the gap between students' level of thinking and geometry, students were taught appropriate to their level of thinking.

The Van Hiele theory (Van Hiele, 1999) proposes levels of geometrical thinking, with five related levels. Each of these five levels defines the thinking processes used in geometric context. The levels of Van Hiele range from concrete structure (level 0) to visual geometric structure (levels 1-2) and to abstract structure (levels 3-4). In addition to the role of intuition, van Hiele's research also discusses the role of instruction that helps students to move from one level to the next (Fuys et al, 1988). It is stressed that the learner cannot achieve a higher level of thinking without having passed through the previous level. The geometric thinking levels defined by the Van Hiele model are as follows:

Visualisation (Level 0): A student at this level determines names and compares shapes depending on their appearances (Kılıç, 2003; Olkun & Toluk, 2003; Knight, 2006; Van Hiele, 1958). At this level of thinking figures are judged by appearance alone and learners at this level may respond by saying: "It is a rectangle because it looks like a door". Also, a student at Level 0 can identify a figure as a square but when the figure was rotated then the student is unable to recognize the figure as a square.

Analysis (Level 1): Students name geometric figures by knowing their properties. Students also begin to distinguish the features of shapes and create classes of figures such as all triangles have three angles or opposite sides of a rectangle are congruent and all of its angles are right angles. Students identify figures such as squares or rectangles. However, these students are unable to identify a square as a special case of rectangle and do not see the relationships between the properties.

Abstraction (Level 2): Students understand the definitions of geometric terms and establish an interrelationship between properties. Reasons about the properties of figures were given at this level. The students can begin to understand that a square is a special case of rectangle because it has all the properties of a rectangle; whereas a rectangle is not a square because all four sides of rectangle are not congruent.

Deduction (Level 3): Students can analyze and explain the relationships between figures and can construct geometric proofs at a high school level. For example, if a figure is a rhombus and a rectangle, then it must be a square. Moreover, undefined terms, definitions, axioms and theorems start to be understood during this level.

Rigor (Level 4): Learner compares different axiomatic systems. Since this final level would be achieved by students in higher education seeking advanced degrees, further discussion of the level will not be provided. At this level, students should be able to know, understand, differentiate and give information about any kind of geometric figure (e.g., Fuys et al., 1988).

Other scholars used different terminology to categorize these levels. Some of them even renumbered the levels from 1 to 5 so that “Level 0” would describe young children who could not identify shapes at all. Both numbering systems are still in use (Mistretta, 2000).

According to Van Hiele (1958), geometry learning is also affected by the time of moving from one level to the next. Since the learning is a discontinuous process, students may need a long time to pass from one level to another, but they must go through all levels. Sometimes, the learning process slows down and may seem to stop, at which time teachers may feel that their instructions are not understood; but it eventually accelerates in time and students would pass to the new level. Mistretta (2000) aimed at increasing the Van Hieles’ thinking levels in a group of 23 eighth grade students by training them to use thinking skills of a higher order.

The results showed the increase in Van Hieles' thinking levels of the students.

In many middle and high schools, students do not have enough experience in reasoning about geometric ideas (Carrol, 1998; Fuys et al, 1988). This may be because of geometry being taught at a symbolic level. So, in order to facilitate the reasoning of geometric ideas and to increase the geometry understanding of the students, the way of giving instructions is also crucial. According to Van Hiele (1999) in order to go from one level to the next, instructions should be given with a well-defined sequence of activities.

As a summary, Van Hiele suggested that a student was ready to prove something if his understanding of the content is at an appropriate level. At this point of view, Van Hiele's greatest contribution with his theory is that differences in reasoning level are under the teacher's control and can be facilitated with appropriate instruction. Therefore, this contribution was mostly taken into consideration in the present study. Moreover, "Van Hiele method was used in this study to develop students' reasoning more appropriately.

2.2. New Elementary School Mathematics Curriculum

The new curriculum has been developed under the guidance of a committee consisting of academicians, teachers, and educational specialists. According to MONE (2004) new curriculum;

- follows a conceptual approach in order to enable the students to comprehend and consider mathematics abstractly by using their intuitions and experiences,
- is based on the fact that the students shall actively participate in the learning process,
- enables the students to express their individual differences and abilities via projects and specific homework,
- aims to prepare environments where students may research, discover and where they may discuss their solutions,
- aims to develop the students psychomotor abilities via using *materials at*

activities,

- aims to provide the students with an education appropriate for the environment they live in via activity samples adaptable to different environments.

New mathematics curriculum is enriched with teaching activities and multiple assessment methods and techniques. There are four learning areas in this mathematics curriculum (MONE, 2004). These four learning strands are the following: numbers, geometry, data, and measurement. Also new curriculum includes the following skills: problem solving, reasoning, communication and connection.

In this study, during ICM, students discover some formulas such as perimeter of square and rectangle on their own, so their both problem solving and reasoning skills might be developed. In addition, students reasoning skills might be improved during this study while they were explaining their own ideas with their own words.

Cognitive skill is one of the other important skills that curriculum gives importance. During the instructions in this study, students used concrete materials, and the aim of using them is to facilitate students'mathematics learning as clearly stated in the new mathematics curriculum. During ICM, discussion was made that leads students to state their own ideas, so their cognitive skils might be improved. Besides the cognitive skills this curriculum gives an importance for the students'affective skills. In this study during ICM, students' get positive affective attitude. Moreover, they enjoyed the classes in which activities were done by concrete materials. This curriculum also gives importance for psychomotor skills. During ICM, students used scissors, and they folded the papers.and these activities helped to develop students' psychomotor skills.

2.3 Concrete Materials

In this section, description and the properties of concrete materials, how to use them, advantages and disadvantages of using concrete materials were explained.

2.3.1 Description of Concrete Materials

There have been many definitions of concrete materials in the literature. In this study concrete materials refers the tools, which are constructed for educational purposes (geoboards, cubes, mason ruler etc.), and real life objects (pipes, toothpicks, sticky tape etc.).

The term "concrete" calls for active touch (Gibson, 1962). Most practitioners and researchers argue that manipulatives are effective because they are concrete. By 'concrete,' they probably refer to objects that students can grasp with their hands. This sensory nature makes manipulatives 'real,' connected with one's intuitively meaningful personal self, and therefore helpful. However, there have been many problems about this view (Metz, 1995). The terms "concrete materials" and "manipulatives" are taken as synonymous to mean "concrete materials that incorporate mathematical concepts, appeal to several senses and can be touched and moved around by students" (Hynes, 1986, p11). Other authors use "manipulatives" to incorporate both concrete and pictorial representations (Touger 1986; Sowell, 1989). Hynes (1986) stated that the terms 'concrete materials' and 'manipulatives' are often used as synonyms to mean concrete materials that incorporate mathematical concepts appeal to several senses and can be handled and moved around by students.

Szendrei (1996) defined concrete materials as real life tools in the classroom Rust (1999) defined manipulatives as any hands-on object that the students' can physically move in order to discover the solution to the problem. According to McClung (1998) manipulatives are objects that appeal to several of the senses. According to Reys (1971) they are objects or things that students are able to feel, touch, handle, and move. Similarly, manipulative materials are described as concrete materials that involve mathematics concepts, appealing to several senses, touched and moved around by the students (not demonstrations of materials by the teacher), and they should relate to the students' real world (Suydam & Higgins, 1976). In making a reference to the world, Heddens (1997) defined mathematics manipulative as any material or object from the real world that children touch and move around to show a mathematics concept. Researchers use 'manipulatives' to combine both concrete and pictorial representations, including images on computers (Sowell, 1989).

2.3.2 The Properties of Concrete Materials

Fielder (1989) and Rust (1999) stated that a proper selection of mathematics manipulatives is essential for students' well understanding and Fielder (1989) outlined some selection criteria. The materials should;

- be multipurpose if possible,
- serve the purpose, for which they were intended,
- allow for proper storage and easy access by teachers and students,
- prompt the proper mental image of the mathematical concept,
- be attractive and motivating,
- be safe to use,
- offer a variety of embodiments for a concept,
- be durable,
- be age-appropriate in size,
- model real problem-solving situations.

Supporting the Fielder's (1989) criteria, Heddens (1997) stated that good mathematics manipulative materials are durable, easily manipulated, attractive, and manageable. Good manipulatives help students in building, strengthening, and connecting various representations of mathematical ideas (Clements, 1999). These findings help to orient this study in the way of how to use concrete materials effectively.

2.3.3 How to Use Concrete Materials?

Strom (2009) stated that an important part of using manipulatives in mathematics instruction is the suitable professional development for the teachers. Suydam and Higgins (1976) added to that argument that if teachers are well trained about curriculum, they will have a positive effect on a child's learning. Sowell (1989) concluded that when manipulatives are used over an extended period of time, teacher's training critically influences their effectiveness.

To begin with availability is probably the most important factor affecting the use of manipulatives in organizing learning environment. Certainly, if manipulatives are unavailable, teachers cannot use them. Nevertheless, Hartshorn and Boren (1990) stated that many manipulative materials are easy to collect and many of them are easy to make.

Organization of manipulative materials is certainly another issue for teachers. There are many types of concrete materials and a variety of ways to use them so the organization of the lesson should be well designed. Ojose (2008) stated that teachers should also assure that choosen manipulatives is adjusted to students' cognitive levels, since all students in a class are not necessarily operating at the same level. To maximize the effect of the teacher's help to a student or a child, it is also important to realize how the cognitive systems develop or in other words, when a child is ready to learn (Bayram, 2004). In addition, teachers need to become extremely familiar with the manipulatives they are using. When selecting manipulatives for the classroom, teachers are all too often looking for them to help students do something instead of have them help the students understand a concept (Thompson, 1994).

Teachers must allow students to work with the manipulatives (Strom, 2009). Supporting this point of view, Szendrei (1996) emphasized that the teacher must give the children materials with precise instructions such as explanation about what to do with them; otherwise the children will simply play with the materials and not learn by using them. After clear instructions from the teacher, students will then start to feel the materials to become extremely familiar with them. Also, how often manipulatives are used is an important factor to consider.

"Asking good and timely questions is an important task of teachers in the process of learning and teaching mathematics that requires knowledge about both mathematics and children's learning of mathematics" (Olkun & Toluk, 2004, p.2). Similarly, Olkun and Toluk (2004) stated that while using manipulatives students should be challenged via questions asked by the teacher who must know the content domain well in order to use questioning effectively. At this point of view, Martino and Maher (1999) stated that asking more open-ended questions can contribute to the construction of a more sophisticated mathematical knowledge by students.

Strom (2009) stated that if materials are used effectively, then all students can and will learn the mathematical concepts taught in elementary, middle, and high school. Supporting ths view, the following suggestions on the effective use of manipulatives were given by Suydam and Higgins (1976);

- Manipulative materials should be used frequently in a total mathematics program in a way consistent with the goals of the program.
- Manipulative materials should be used in conjunction with other aids, including pictures, diagrams, textbooks, films, and similar materials.
- Manipulative materials should be used in ways appropriate to mathematics content, and mathematics content should be adjusted to capitalize on manipulative approaches.
- Manipulative materials should be used in conjunction with exploratory and inductive approaches.
- The simplest possible materials should be employed.
- Manipulative materials should be used with programs that encourage results to be recorded symbolically.

Teachers' own views on manipulatives, if biased in a negative way, adversely affect their role in using them. According to recent studies in Turkey, some factors that influence teachers' view and use of manipulatives are; covering the curriculum in a limited time, having problems with classroom management, availability of the materials, teachers' ability to use manipulatives in mathematics lessons and students' excitement and motivation toward activities (Çakıroğlu & Yıldız, 2007). In this point of view, as a researcher and also teacher of the classes, if it was believed that there have been positive effects of using manipulatives, then the teacher overcome time limitation problem. It was stated that a remark commonly made by teachers who disliked using concrete materials in the classroom was generally like: "Mathematics is abstract. We would like to create abstract concepts in the pupils' minds. They will mix concrete objects like blocks, sticks, and so on with the mathematical concepts" (Szendrei, 1996, p. 429).

Howden (1986) advocates that manipulatives are particularly useful in helping children move from the concrete to the abstract level. Howden's (1986) view was similar to Heddens' research (1986) that manipulatives help children in moving from the concrete to the abstract level. In addition, Howden (1986) stressed the need for the teachers' role in building a bridge between the concrete and abstract using manipulatives and that it requires careful attention. He added that a problem may occur if the bridge is not structured by not using appropriate manipulatives.

McClung and Lewis (1998) supported Howden's view and they stated that that concrete materials are the bridge between the real world and the mathematical world. But, it is not easy to plan a process that can realize the journey from concrete material to abstract mathematical content. Post (1981) illustrated the relationship between the real and mathematical world as follows:

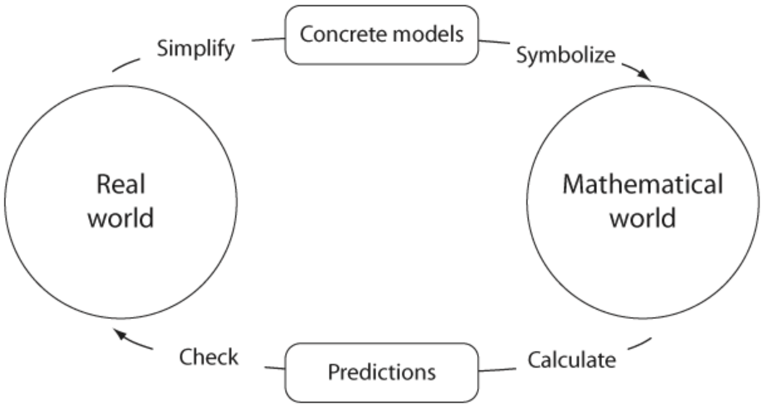


Figure 2.1 The Relationship Between Real and Mathematical World

According to Szendrei (1996), it is not easy to make process plans that cover from concrete material to abstract mathematical content. In such transition, teachers' roles become more important. Likewise Garrity (1998), Durmus and Karakırık (2006) stated that using manipulatives in a class is not straightforward and good employment requires carefully defining the role of the teacher and identifying the aims and the potentials of the tasks involved. A common but extreme view of the use of concrete materials in mathematics teaching is that the teacher's role is only to create a laboratory and put the child in it and then the mathematics learning process automatically occurs (Szendrei, 1996). The process however is not so simplistic in many cases.

2.3.4 Advantages and Disadvantages of Using Concrete Materials

Heddens (2005) argued that using manipulative materials in teaching mathematics classes will help students learn:

- To relate real world situations to mathematics symbolism.
- To work together cooperatively in solving problems.
- To discuss mathematical ideas and concepts.
- To verbalize their mathematics thinking.
- To make presentations in front of a large group.

- That there are many different ways to solve problems.
- That mathematics problem can be symbolized in many different ways.
- That they can solve mathematics problems without just following teachers' directions.

In addition, Reys (1971) explained the benefits of using manipulatives by stating that they add variance to classroom activities, generate experiences in problem solving, provide opportunities to the students in discovering relationships and making generalizations, and provide a basis for analyzing sensory data. Szendrei (1996) stated another role of manipulatives as helping pupils to develop new skills that are not developed through out-of-class experience. Rust (1999) argued that manipulatives can also help people who learn better in different methods of teaching rather than simply through the traditional method.

Even though many studies discussed the similar advantages of concrete materials with Rust (1999), in some cases, the usage of the same manipulative can turn out to be harmful for mathematics learning. This is pointed out by Heddens (2005) as well who stated that as with any cure, manipulatives hold potential for harm if they are used poorly. An example that holds potential for harm and that is associated with the early language learning process can be given as follows:

The teacher holds a ball in her hand and says: “This is a sphere.” The child’s parent, on the other hand, could have shown a red ball to the child when the child is younger and said, “This is a red ball”. This conflict could emphasize the color more than the shape for the child to remember. The teacher must have chosen the appropriate materials. The famous Hungarian mathematician Laszlo Kalmar said that a concept is like a baby: It must be baptized only after its birth.

According to Szendrei (1996), educatioanal philosophies differ from each other in the way they think concrete materials should be used or not in the mathematics classes because of the disadvantages of using them. As a result of these findings philosophies, in some systems mathematics is regarded as a subject that needs only a blackboard and chalk, paper and pencil, ruler, compass, tables (and maybe calculators) as educational materials, whereas in other systems, unique and colorful manipulatives (like chips, counters, sticks) can be used in early childhood, to be replaced with the understanding that everything can be discussed without using either common tools or educational materials for later ages (e.g, after 10 years).

One of the most common disadvantages of using concrete materials is experienced in situations where the materials were not appropriate for the subject and teachers claim that materials were not useful at all. These kind of situations sometimes lead teachers to eliminate the materials from education altogether. Similarly, because of the difficult usage of some of the concrete materials, teachers could also give up on using them (Thompson, 1994). Lastly, some studies argued that concrete materials are likely to be misused when a teacher only believe that students will learn to perform some prescribed activity with them (Resnick and Omanson 1987; Boyd 1992; Thompson and Thompson 1994).

In addition to some disadvantages, Szendrei (1996) have cautioned against using concrete materials in the classes with arguments such as the following:

1. There will be noise in the classroom.
2. The children will destroy the materials.
3. The cost of education will become disproportionally high.
4. The concepts that are developed using concrete materials will never become abstract.

2.3.5. The Research Studies on Concrete Materials

Concrete materials have a long history in mathematics classes and have been used since 16th century. Both Pestalozzi, in the 19th century, and Montessori, in the early 20th century, defended the active involvement of children in the learning process (Szendrei, 1996). In support of this view, in order to engage students interactively and entertaining for the purpose of learning in mathematics, teachers must involve students physically in hands-on learning (Allen, 2007). Haury (1994) defines hands-on learning as learning by doing.

Today there are hundreds of materials in use (Szendrei, 1996). Hartshorn and Boren (1990) stated that the National Council of Teachers of Mathematics (NCTM) has encouraged the use of manipulatives at all grades in every decade, since 1940.

Much evidence on the importance of concrete materials can be found in many studies from different aspects (Heddens, 2007; Hartshorn & Boren, 1990; Suydam and Higgins, 1976; Allen, 2007; Canny, 1984; Caine & Caine, 1991; Strom, 2009; Elswick ,1995; Durmus & Karakırık, 2006; Heddens, 2007; Witzel, 2007; Moch, 2001; Howden, 1986; Moyer, 2001; McClung, 1998; Bayram, 2004; Olkun & Toluk, 2004; Bayram, 2004; Yıldız, 2004; Cakıroglu & Yıldız). The most comprehensive review of research on the use of manipulative materials was collected by Suydam and Higgins (1976). The summary data of the studies that used manipulative materials with regards to achievements in mathematics is given in Table 2.3.1 (Suydam & Higgins 1976, p. 33).

Table 2.3.1 Summary of Grade-Related Studies Dealing with The Impact of Manipulative Materials on Students' Achievement

Grade	Number of Studies Favoring Manipulative Materials	Number of Studies Favoring Non-manipulative Materials	Number of Studies Showing No Significant Differences	Total
1 and 2	7	2	3	12
3 and 4	9	1	3	13
5 and 6	6	0	3	9
7 and 8	2	1	3	6
Total	24	4	12	40

Suydam and Higgins (1976) argued that studies were similar in nature to those found in earlier reviews of research dealing with manipulative materials. According to the table, it is seen that 60 percent of the research studies examined favored the manipulative treatments, while only 10 percent clearly favored the non-manipulative treatment in all grades. The table results also show that 9 out of 13 studies put a conclusion that in grades 3 and 4, students after having instructions on the use of manipulative materials, scored significantly higher on achievement tests.

Some of the researches support the view of the positive achievement effects of concrete materials (Heddens, 2007; Allen, 2007; Battle, 2007; Sowell, 1989). Suydam and Higgins (1976) and Allen (2007) also emphasized the assistance of manipulative materials in greater mathematical achievement when they were used properly. An example supporting research can also be stated here: that took place in England, Japan, China, and the United States advocating the idea that mathematics instruction will be more effective if manipulative materials are used (Heddens, 2007). Many of the mathematics subjects are generally seen as abstract for the children. For this reason, additional materials which will act like a bridge from the abstract to the concrete are needed. Howden (1986), Thompson (1994), Moyer (2001), McClung (1998), Suydam and Higgins (1976) argued that concrete materials assist students in bridging the gap from their own concrete sensory environment to the more abstract levels of mathematics. The same argument was stated by Battle (2007) as well, that materials are the bridge to fill the gaps of students' conceptual knowledge.

CHAPTER 3

METHOD OF THE STUDY

In the previous chapters, problems and hypotheses of the study were presented, the related literature was reviewed accordingly and the essence of the study was justified. This chapter explains the research design of the study, subjects of the study, development of the measuring instruments, teaching/learning materials, and analysis of the data, assumptions and limitations, internal and external validity.

3.1. Research Design of the Study

In the present study one-group pretest-posttest design was used (Fraenkel,1996). The Geometry Achievement Test (GAT) was administered during the present study. In Table 3.1 the research design of the present study is shown.

Table 3.1 Research Design of the Present Study

Pre-intervention measuring instrument	Treatment	Post-intervention measuring instrument	Follow-up measuring instrument
GAT	ICM	GAT Interview	GAT

In Table 3.1, the abbreviations have the following meanings: ICM represent instruction with the "Concrete Materials". The measuring instrument in Table 3.1 is Geometry Achievement Test (GAT). The GAT was administered three time period (pre-intervention, post-intervention and follow-up). After post- intervention, 11 students were selected to interview. The general purpose of interview questions was to have student's opinions and feelings about the instructions with concrete materials.

3.2 Subjects of the Study

This study took place in one of the private schools in Ankara-Turkey in 2008-2009 academic years. The school provided for students in kindergarten to 12^{th} grade. There are approximately 1500 students in the school. 150 of those are 4^{th} grade students. The present study was conducted with two of six 4^{th}grade classes. In the present study one group pretest-posttest design was used (Frankel and Wallen, 1996). They were administered to 32 fourth grade students who were taught the same mathematical content with the same textbook in the same period of time. The gender distribution of the study sample is almost equal.

Table 3.2 gives information about the total number of students, the number of girls and boys in two classes who participated into study.

This study was conducted in two fourth grade classes each ranging in age from 9 to 10 years old. There are 41 students in two classes since students who did not take both tests were removed from the study, 32 of the students participated in this study.

Table 3.2 Total Number of participants, The Number of Girls and Boys

Class	The Number of participants	Number of girl participants	Number of boy participants
I	13	5	8
II	19	11	8
Total	32	16	16

According to Table 3.2, the total number of girl participated in the study is equal to the total number of boys.

3.3 Procedure of the Study

In this section procedure of the study is explained.

1. The study began with the review of literature about various aspects.

2. Prior to beginning the study, all necessary permissions were obtained from the General Directorate of the private school.

3. The GAT and interview was developed by the expert and reasearcher.

4. Activities were prepared using appropriate concrete models as recommended by researches in the literature (see Appendix D).

5. The researcher gave ICM to the two classes.

6. The study was conducted for 10 weeks with 32 fourth-grade students in 2008-2009 academic years.

7. The data obtained from the GAT and interview were analyzed and used in reaching conclusions about the problems of the study.

3.4 Development of the Measuring Instruments

In the present study, Geometry Achievement Test (GAT) was administered and the interview was conducted. Both measuring instruments were presented in Turkish in order to overcome the language barrier. They were explained in this section.

3.4.1 Geometry Achievement Test (GAT)

The Geometry Achievement Test (GAT) was developed by the researcher and the expert to determine the students' geometry achievement over three time periods: pre-intervention, post-intervention, and follow-up (see Appendix A).

The procedure and the process used in developing the measuring instruments were explained below step by step.

1. To establish the content validity, according to the objectives, a table of specification was prepared (see Appendix B).
2. An item pool which has 45 questions was prepared. The questions were classified according to basic geometry concepts.
3. 16 questions were selected from the item pool.
4. While selecting the 16 questions, experts' and teachers' opinion were taken in consideration.
5. A pilot study was conducted to determine the validity and reliability of the test. 52 fifth grade students from two classes in the same private school were chosen for the pilot study.
6. After the pilot study, students' opinions, the middle school mathematics teachers' opinions and experts' opinions about GAT were taken. Based on their comments, the test was reorganized.
7. A rubric was prepared for GAT. The opinions of three mathematics teacher were taken while preparing the rubric. In addition to mathematics teachers' opinions, expert judgment was also taken in consideration. According to the rubric, the maximum score that students can get from GAT is 80 while the minimum value is 0. Rather than a single numerical value, the rubric also gives a detailed guide to the evaluator (see Appendix F).
8. Two mathematics teachers evaluated the pilot study according to the rubric to determine the inter-rater reliability. By using the SPSS program the inter-rater reliability analysis was conducted.The pearson product moment correlation coefficient was found as 0.960.

Before conducting the pilot study two students were selected to work on the understandability of questions. The wording of the questions was updated after receiving the feedbacks of students. Then pilot study was conducted with 52 students. After student completed the pilot test, researcher spoke with some of fifth grade students whether they understood questions or had difficulty about the meaning of the wordings. Moreover, students were asked whether the testing time is sufficient or not. All of these feedbacks were noted. According to the notes, the pilot study denoted that the testing was sufficient but some of the words were not clear for the students. For example, students said that the question number 14 was not clear.

Question # 14 (in pilot study)

As for homework, Bilge draws a triangle and cuts of this triangle. But while cutting of the triangle, she mistakenly cuts of its corners. Her teacher asks her to bring together the cut off corners. What type of angle has she obtained? Explain.

The wordings and meaning of the statements were reexamined and new modifications were performed. So the question scenario was changed but the content remained same. It was also strictly preserved that the questions measuring the same objective. In order to make the question more understandable, a figure was added. After these modifications, the test was given to one of other mathematics teacher who is also responsible for fourth and fifth grade mathematics classes. Feedbacks were taken from the mathematics teachers and experts. By regarding the feedbacks, some of the figures and pictures were redrawn, and some of the sentences were decreased and became more understandable. In addition, a scenario was added to question # 15.

After the pilot study, GAT was applied to two fourth grade classes three times. It was used to determine the students' geometry achievement. The instruments used in this study included a pre-intervention, constructed by the instructor which covered the learning outcomes that would be tested during the study. The questions asked in post-intervention and follow up were identical to pre-intervention but the students were not told about that. They were both administered to obtain the data needed.

3.4.2. Interview

In order to support inferential findings of the study, gathering specific information regarding the students' opinion about instructions on concrete materials was needed. So, interview was selected as a data collection method.

Before the interview the concrete materials which were used during the treatment were reminded. Those concrete materials are: cubes, mason ruler, geoboard, pattern blocks, symmetry mirror, straw, tangram, geometry strips, geometric objects, isometric grid, and grid paper.

The interview questions were categorized into two parts. The first part of the interview includes questions to have opinion about the students thought towards mathematics.

- *What do you think about Mathematics class? Why?*
- *What comes to your mind when you think about Math?*

The second part of the interview includes questions to have opinion and feelings about instructions with concrete materials. Students' answers were categorized as "enjoyment", "anxiety", "easiness", "usefulness", "fondness" and "relations with other courses". Here are some examples of second part questions:

- *How do you feel when you second time see the questions (post-intervention) after using the concrete materials?*
- *How do concrete materials affect your understanding of geometry? Explain.*

The interviews were transcribed and they are presented in appendix H. Two people coded the interview answers of students. Since students clearly stated their opinions, the two codings were same, so the reliability of the coding of th interview was satisfied.

After the interview, answers were categorized and compared. The purposes of interview questions are given below in Table 3.4.2.

Table 3.4.2 Interview Questions and Their Purposes

Questions	Purpose(s) of the Questions
What do you think about Math class?Why?	To examine the students' feelings about Mathematics.
What comes to your mind when you think about Math?	To get their first opinion about Mathematics.
How do concrete materials effect your geometry problem solving?Explain.	To investigate whether or not students' Geometry problem solving method show changes with concrete materials.
How do you feel when you first see the questions (pre-intervention) before using the concrete materials?	To examine the students' feelings **before** using concrete materials.
How do you feel when you second time see the questions (post-intervention) after using the concrete materials?	To examine the students' feelings **after** using concrete materials.
How do concrete materials effect your understanding of geometry? Explain.	To investigate the cognitive effects of concrete materials.
Do the activities effect your understanding of geometry during your study of that concept? Explain.	To got vision of students about what do they think about activities, and their emotional feelings about this question.

Table 3.4.2 (continued)

Questions	Purpose(s) of the Questions
Which one of the concrete materials was useful for you? Why?	To get information about which one of the materials is most useful for them and the reason for it.
Which one of the concrete materials do you like most? Why?	To get information about which one of the materials they like most and their reasons.
How do you feel while using concrete materials? Why?	To investigate the emotional feelings while using concrete materials and the reasons.
With which courses were you able to make a relation with geometry during performing activities with concrete materials?	To understand whether they make a relation with geometry and other courses. Moreover, it is expected that studentswould say the name of the courses.

The interview was conducted after the post-intervention. It had 11 questions and was conducted with 11 students from two classrooms. Students who were interviewed had different achievement grade levels according to the previous semester's notes. Five of the students' mathematics achievement grade is 5, five out of 11 students' mathematics grade is 4 and one of the students grade is 2. Students were informed about the pre - intervention and post intervention before interviewing. Also, interview questions were given to the students while interviewing. Moreover, the aim of the interviews was explained in details for students to make themselves feel comfortable. It was reminded to students that giving the right answer was not expected, the only important thing is their opinion about the questions. It was the first time for students to attend such an interview so they were excited and a bit nervous. A funny dialog was conducted with students to decrease their anxiety. A tape recorder was used to record data during interview with the permission of students. This interview was conducted outside the students' classroom environment one by one. Each interview took approximately 10-15 minutes for each student. Interview questions and their purposes are included in appendix G.

3.5 Teaching/Learning Process

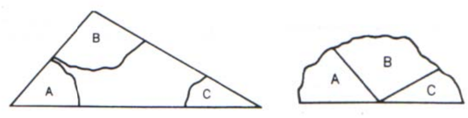
In this section, the procedure of ICM and development of activities were explained.

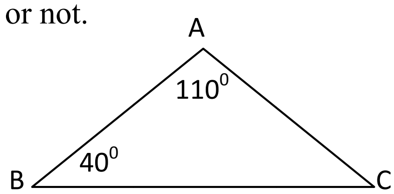
3.5.1 Development of Activities

During ICM, many activities were implemented regularly. In the development of activities and instruction some of the theories and the findings of research studies were utilized. One of them was Piaget's (1973) theory. Many researches pointed out the importance of the activities during learning. Piaget (1973) believed that students should do free activities during learning process. Piaget drew attention that classroom learning should include both independent and collaborative student activities. Likewise Piaget (1973), Dienes (1971) concerned with active student involvement with the use of a big amount of concrete materials. Students can remember the subject through material when they are actively engaged in the learning process (Bonwell & Sutherland, 1996). Suydam and Higgins (1976) suggested using concrete materials in activities to bridge the gap between the concrete and abstract levels. Weisskirch (2003) stated that active learning environment must be planned according to learning outcomes. Finally, the Bruner's theory of instruction was utilized.

In the present study, after pre-intervention, different activities were performed with students in 10-week period. During some activities, teacher guided discovery learning was used. In these activities, the first step involves discovering a formula and the second step requires the students to use the formulas in problem solving. According to Bruner (1961), discovery learning develops cognitive and critical thinking skills of the students.

In the sample activity given below, a triangle was drawn by students. Then, the corners of the triangle were pulled away as shown in the figure. Then, the pieces were put together. Students were asked what type of angle did they get and whether their answer give the sum of interior angles of triangles or not.





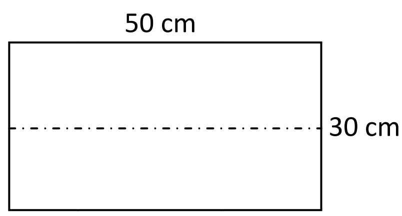
Students were asked to write their findings first in verbal. Verbalization is important in developing thought process skills of students. As Heddens (1986) suggested, providing students with opportunities to verbalize their thought process helps to clarify their own thinking. These types of activities were followed by problem solving. For example, students were asked to solve the problem by using the formulas they discovered such as:

Find the value of given in triangle *ABC*?

During ICM, problems were also asked to improve their problem solving ability. For example;

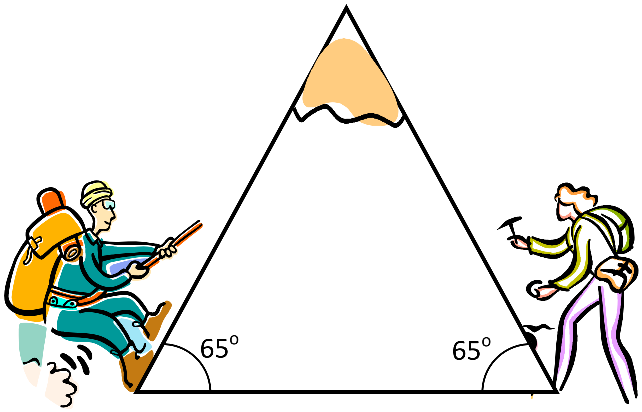
Problem 1:

The given paper to the right is a rectangle whose short side is 30 cm and longer side is 50 cm. Using a scissors, the paper is cut in two equal pieces as shown. What is the perimeter of one of the pieces? Explain.



Purpose of Problem 1: To find the perimeter of rectangle. To overcome the misconception that the perimeter of the shape that is half of the rectangle is equal to half of the given rectangle.

Problem 2: Two climbers climb the mountain like in drawings on the right. The angles between the ground and two different sides of the mountain are equal to 65° which were given on the right. Compute the ungiven angle? Show your result and explain.



Purpose of Problem 2: To determine whether students can find one of the interior angles of a triangle when the other angles were given.

As underlined by Sowell (1989), children should have enough concrete experiences before they are asked to work abstractly. Bayram (2004) stated that once a concept has been introduced using the concrete materials, pictures, and diagrams, the learner are ready to use numerals and symbols (abstract materials) with understanding. According to Weisskirch (2003), activities let students to apply the stages of Piaget's theory of cognitive development and with activities students' understanding of the concepts increases.

In the present study, all of the activities were prepared by researcher according to these topics: Angles, triangle, square, rectangle, symmetry, perimeter of planar shapes, area of planar shapes and geometric shapes. In the activities, CD's, CD cover, toothpick, pipes, geoboard, symmetry mirror, mason ruler, cubes, geometry strips, pattern blocks, isometric grid, grid paper and protractor were used as a concrete materials . First, the steps of the activities were explained and one copy of the activity sheet was given every student or each groups. Some of the activities which were used during treatment are follows:

The first sample activity titled as "Let's complete the tessellation". It was performed for one lecture time and the lecture took 45 minutes. Firstly, before giving the pattern blocks, students were given time to think about tessellation in the real world. Then, three or four people group was constructed. Each small group was given a sheet of activity paper by the researcher. The activity started with the selecting suitable patterns for their own tessellation. They were informed that the activity was a competition and that there would be a winner. The winner would be rewarded with stickers. Students also were informed that they work together. The role of researcher was to examine students' work and answer their questions. During the activity, teacher also guided students' workings. The important thing in this activity was not to leave any empty spaces while doing tessellations. At the end of the activity, all groups clapped for the other groups and the group which got the highest applause became the winner.

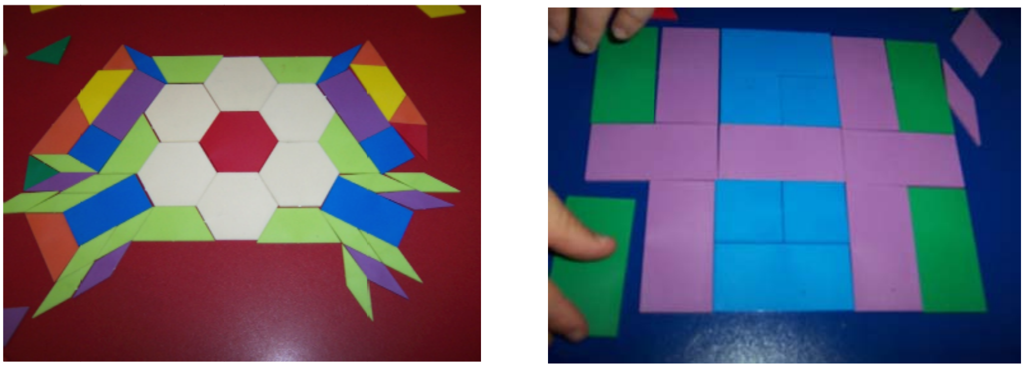


Figure 3.3 Students' are Working on Tessellation Activity

The other activity was related to symmetry. This activity was performed for one week 5 lecture times. Three types of activities about drawing the symmetrical shape of a given shape using symmetry mirror, constructing the symmetrical shape of given shape by using geoboard and drawing symmetric lines of the given shapes by using symmetry mirror. Activities were performed both individually and in small groups. Students were also encouraged to discuss their answers and strategies with their partners. Worksheets were distributed to each student during activities.

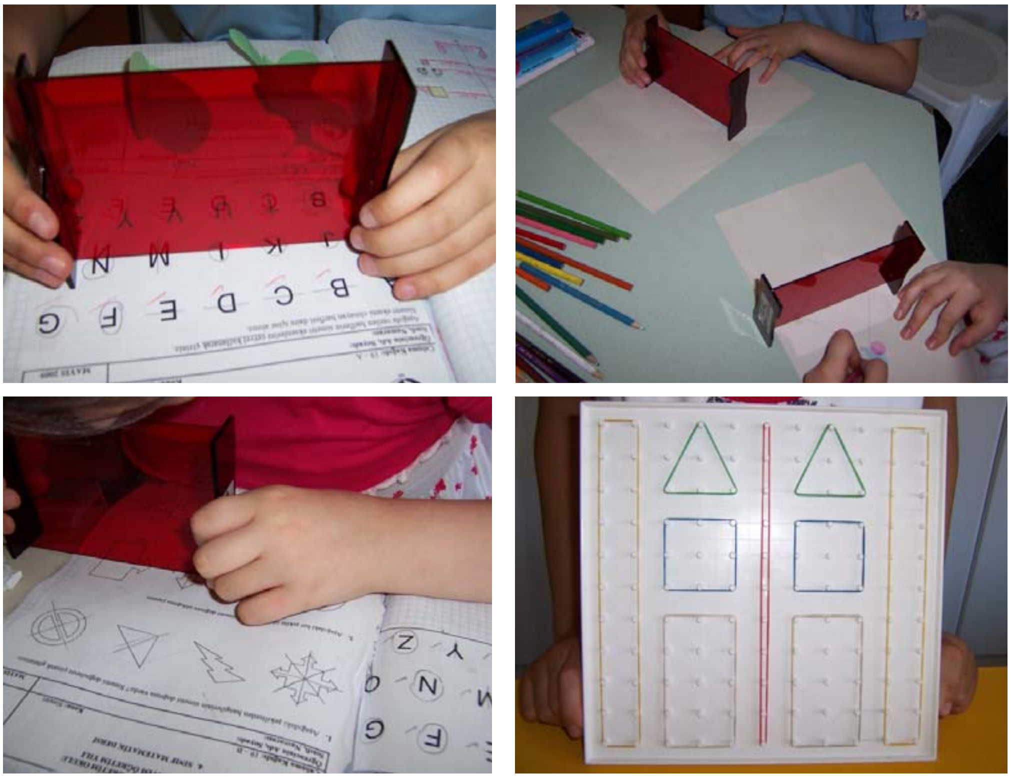


Figure 3.4 Students are Working on Symmetry Activity

The other sample activity titled as "Constructing Triangles" was administered to the students to identify the types of the triangles according to their sides and angles. These activities were performed for one week during five class periods. In these activities, students were expected to construct acute, obtuse, right angled, equilateral, isosceles and scalene triangles. Students were asked to construct triangles on their own and by using their protractor. The teacher role was observing the students while they are working. Also, students' protractor usage was examined. The teacher also had a role about asking challenging questions, such as "Can you construct a rectangle by using two acute triangles?" According to the students' answers, another further challenging question could be how to make a square with two rectangles. In each case, students were asked to show and explain their answers, and were allowed to discuss the questions with their partners before answering. After they found the answers, they asked the teacher to come and check their results.

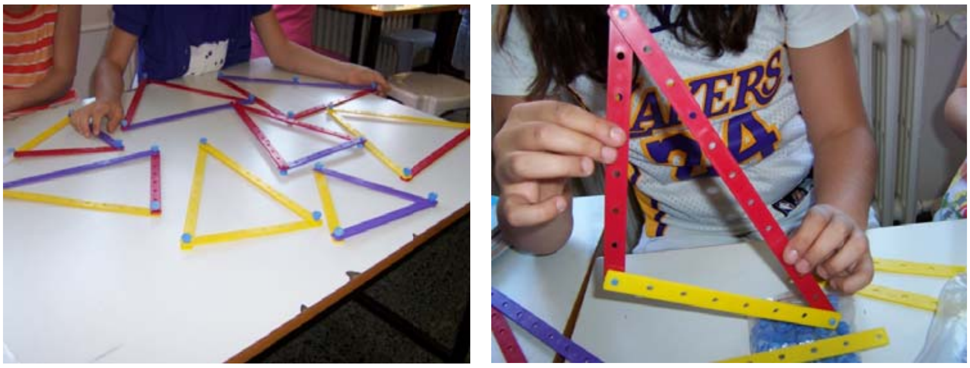


Figure 3.5 Students are Working on Triangles Activity

The other activities were about constructing shapes with cubes as given in the isometric grid paper. This activity was performed for one week, 3 lecture times and each lecture took 45 minutes. Each activity consisted of constructing 10 different shapes, and was carried out in a competitive way. The time was given students to built up both shapes then at the end of the time the group which did not have any mistakes became the winner. At the end of the activities a five time pop quiz was also given to the students. Other examples of activities are presented in appendix D.

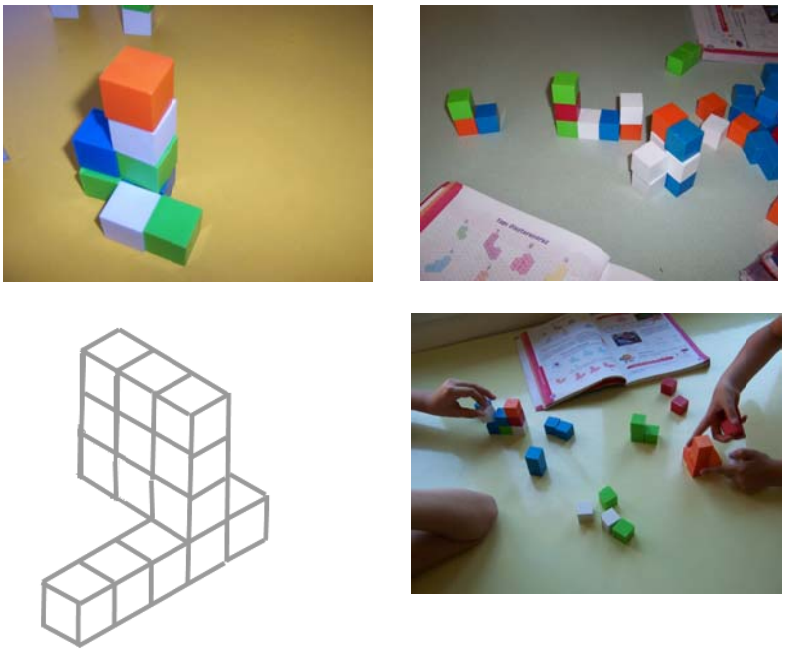


Figure 3.6 Students are Trying to Construct Given Shapes with Cubes

Also, at the end of the activities, chances were given to the students to explain what they have learnt about the subject. The teacher helps students while they were wording their thoughts. Moreover, they were asked to explain their observations and their ideas. Also, the students learnt new strategies by listening to each other's clarifications. The teacher wanted them to support their ideas by giving examples from the activities. In the classroom, discussion atmosphere was set about their conclusions. The teacher did not intervene while students were stating their ideas. Instead of correcting the students' ideas, teacher had a big role for giving cues so students can find their own mistakes on their own as well. Teacher should monitor while students were discussing. The students would not avoid from telling their ideas since the teacher did not punish students for what they had said. So, students were motivated and given a chance to increase their positive attitudes towards geometry. Since the students were active in the classroom most of them tried to raise their hands to answer questions, so there exists an amazing social interaction. At the end of the discussion teacher summarized and corrected student's faults one by one.

3.5.2 Instruction with Concrete Materials

During ICM 50 hours of geometry class were taken in a ten week period. In order to m ake an effective ICM learning environment, first students were motivated. The teacher is the researcher in this study. At the beginning of the lesson, teacher told some funny jokes. Then students were engaged in developing geometrical concepts in real and relevant context. Then, a five minute daily life conversations were made about the subject. For example; at the beginning of the 'Angles subject, teacher started with questions that wanted students to give daily life examples of angles. After taking the answers from students, some daily life examples were shown through pictures by displaying them on the computer.

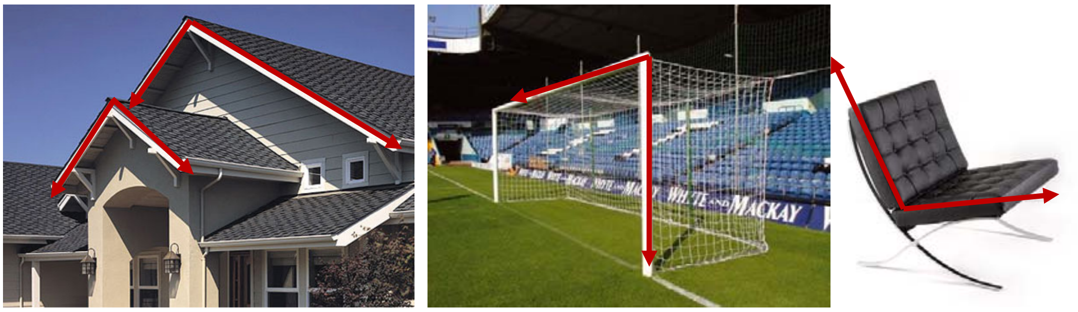


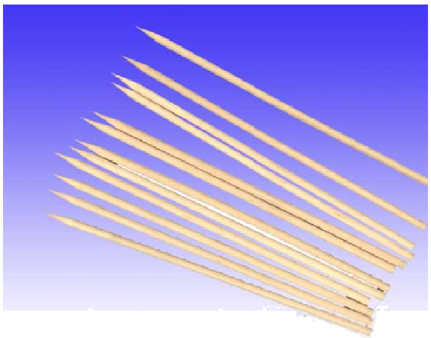
Figure 3.7The Daily Life Examples for Angles

Moreover, examples were shown by using concrete materials about the subject such as; showing angles with mason ruler as seen in the below figures.

Figure 3.8 Constructing Different Angles with Mason Ruler

The problems were chosen considering the situations which the students could meet in daily life. It was expected from the students to use their pre-knowledge to look for answering the problem. In order to prepare learning environment according to a planning manner, lesson plans were needed. The lesson plans (see appendix C) were constructed according to the annual plan which was prepared at the beginning of the related academic year. So, the subjects were taught with a determined timeline. Since the learning process was determined according to lesson plans, teachers have also a great responsibility while preparing them. Teachers must also organize time management of lesson well. In lesson plans there were many exercises, problems and pop quizzes. Both of them were prepared by three mathematics teachers who were teaching fourth grade mathematics course.

In the present study, during ICM, teacher frequently asked different types of questions to students since questioning is an effective tool to guide students through exploration. For example;



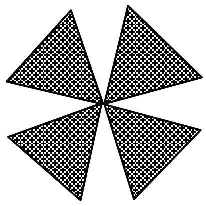
Questions:

1. Can you make a square by using four toothpicks?
2. How can you make it?
3. Now, can you make a rectangle by using four toothpicks?
4. How many of the toothpicks would you use to make the smallest rectangle?
5. Can you put the toothpicks to the diagonal of your rectangle?

There were a lot of students saying “Yes” to question number one but could not make the square. Moreover, some students’ answers were creative as they could make a rectangle using four toothpicks by breaking them into pieces. In order to make the smallest rectangle, most of them used 6 toothpicks. Also, they could put toothpicks to one of the diagonal of the rectangle, but most of them forgot to show other diagonal of the rectangle. This was partly due to the fact that most of the students did not use such kind of material before. Olkun and Toluk (2004) supported to the view of teacher questioning since an inquiry – based classroom environment was constructed. Content of the asked questions was also very important (Olkun & Toluk, 2004). Martino and Maher (1999) shared the idea and stated that open-ended questions force students to think deeper and more creatively. Olkun and Toluk (2004) also emphasized that the timing of the questions must also be taken in consideration.

During ICM, many exercises about the subject were carried out. Some exercies were noted to students’ notebooks, some of them were given as a worksheet. The exercises were mostly done at the blackboard step by step. Questions were frequently asked whether students understood the solution steps. An example from the exercise has been given below.

Exercise 1: The below figure was constructed with four equilateral triangles. If the perimeter of the figure is 156 cm, then find the length of a side of the equilateral triangle?

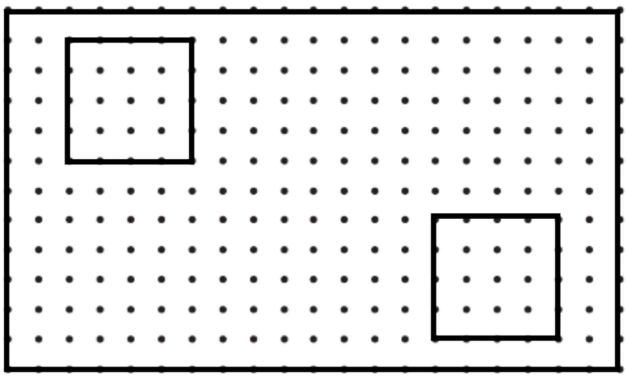


Purpose of exercise 1: To determine whether students find the perimeter of triangles or not.

Exercise 2: Ali is suffering from symmetry sickness. He wanted to put four plates on the table as shown the figure below.

a) In order to make the plates' positions symmetric within the table, place the other two plates in appropriate positions. Show your result and explain.

b) Draw the symmetry lines of the table.



Purpose of exercise 2: To determine whether students complete given symmetric figures. Also another aim of the question is to check students' symmetric line drawings.

Sample worksheets are presented in appendix I.

At the end of ICM, short quizzes which took 10-15 minutes were applied. Quizzes included few conceptual questions regarding to the topic of the activity. The purpose of the quiz is to conclude whether they learned the topic and encourage them to the following lessons. When students finished their quizzes, teacher collected quiz papers. Pop quizzes were evaluated by three teachers. The result of pop quizzes was given to the students the day after quizzes were administered and they were sticked on students' notebook. So, students did not have any chance to lose their pop quizzes and they could see their incorrect answers whenever they want. Also, in the following day, at the beginning of the lesson, questions' answers were given to the students. According to the results of quizzes, teacher pass quickly over the related topic which most students' do not have any mistakes, and stressed on the points which were understood weakly. After studying the lesson, teacher again asked, whether students had questions about the topic. If students did not understand the topic well, students were advised further activities and studies.

The school principal created all the fourth grade classes on the basis of establishing a diverse range of gender and courses ability level. This means that the fourth grade students were selected carefully in order to make classes heterogeneously. Mathematics was taught to the same group of students throughout each day in the same classroom with mathematics teachers not with classroom teachers. All classes have five hours mathematics lessons in a week. According to the school principle, one of this math classes must have been studied in "Math Club". "Math Club" is a kind of Math laboratory. In this Math Club, there are varieties of mathematics and geometry materials in which to use through first grade to fifth grade.

3.6 Validation of Treatment

Observation checklist was used to check whether the treatment was applied or not. During the activities, observation check lists were filled by teacher candidate five times in different lessons.

The observation checklist which was used in the present study consists of four parts (See appendix J). The first part is related to physical conditions of classroom, the second part is related teachers' behaviors, their relations to students, and reinforcements given to students. The third part is about the students' behaviors;

whether they eagerly want to participate or not to the lessons. The final part is related the method; it asks teacher whether the lesson is conducted stıdent centered or not. The questions were rated on a 3-point likert type response format (Yes, no or partially).

The subjects of the lessons that observation check lists were filled are listed, also the used materials and the date were stated below.

- Subject: Symmetry, Materials: Geoboard, Symmetry mirror, Date: 12.05.09
- Subject: Finding Perimeter of squares, Materials: mason ruler, pipes, sticky tape, Date: 05.05.09
- Subject: Finding Perimeter of rectangles, Materials: geoboard, Date: 06.05.09
- Subject: Types of triangles according to their lengths, Materials: mason ruler and protractor, Date: 21.04.09
- Subject: Types of triangles according to their sides, Materials: mason ruler and pipes, Date: 23.04.09

According to the observation checklist result (see Appendix J). All observers marked “Yes” in all items. In other words, it was shown that ICM was applied.

3.7 Data Collection

Before the start of this study permission was requested and obtained by the school. The pre-intervention was administered on March 24th, 2009 and the post-intervention was administered on July 9th, 2009. After the two months summer break of the school the follow-up was applied on October 1th , 2009.

3.8 Analysis of the Data

In the present study, SPSS package program was used to analyze the data. Firstly, students’ scores for each part of the SAT were transferred to SPSS package program. Then, descriptive statistics were used to get the means and standard deviations of the students' SAT scores. Also, descriptive statistics was used to find the distribution of the number and the frequencies of the subjects. Moreover, by using this statistics outliers were found and data cleaning was made.

In this study, one-way repeated measures ANOVA was used to analyze data. It was used to determine whether there are significant mean differences among students with respect to their SAT scores. The sub-problems of the study will be examined by means of their associated hypotheses which are in the null form and tested at a significance level of 0.05.

3.9 Variables

The variables of the first main problem are pre-intervention, post-intervention and follow-up test scores of the students they got from ICM as dependent variables.

The variable of the second main was problem students' opinion and feelings about ICM.

3.10 Internal and External Validity

In this section internal and external validity of the study are discussed.

3.10.1 Internal Validity

Internal validity of a study means that observed differences on the dependent variable, not due to some other unintended variable (Fraenkel &Wallen, 1996). A subject characteristic is one of the possible threats to internal validity of a study. In the present study, the students in both two classes were at the same ages. Also, the number of girls and boys were the same and approximately most of the students'socioeconomic levels were similar. Therefore those traits did not influence research results accidentally. Another threat is history. The pre-intervention and post-intervention, as well as the 10-week visual treatment were administered at the same school and there was no such an event those effect students' responses and study procedure so; the history threat was controlled. There was a 5 week break between post-intervention and follow-up to eliminate the effect of testing. In order to eliminate location threat, all students were administered at the same time and same place controlled. In addition, measuring instruments (GAT) wasn't changed during the study which controls the instrumentation effect. Instructor performed each activity over the same period of time to eliminate maturation effect. There was no such a control group that students perceive that they are receiving any sort of special attention so; attitude of subjects eliminated. Since classes are mixed as students have different teachers until fourth grade, it was not possible to ask the teachers whether the students are familiar with concrete materials or not. So, there may be a novelty effect. In addition, there was no such a student with extremely low or high scores on test so; regression to mean effect was eliminated. Lastly, there were 10 weeks between pre-intervention and post-intervention and there was a 5 week of summer break between post-intervention and follow-up to eliminate the testing effect.

Mortality is another threat to internal validity to control. As it was mentioned before some students were lost during the study. For instance; 5 of them did not participate in the post-intervention To eliminate mortality effect, missing data analysis was conducted. Students who did not complete both pre-intervention, post-intervention and follow-up were determined and their total scores were regarded as missing. The variables that have missing subjects were analyzed for significance using SPSS and there is no statistically meaningful difference was found between the averages of the retention test scores (follow-up results) of those students who participated in the post-test and those who did not ($t= 1.776$, $df=35$, $p>0.05$). Moreover, 4 students did not participate in the retention test. No statistically meaningful difference was found between the averages of the post-test scores (follow-up results) of those students who participated in the retention test and those who did not ($t=0.720$, $df=34$, $p>0.05$). So, mortality effect was eliminated.

3.10.2 External Validity

External validity is the extent to which the results of a study could be generalized (Fraenkel & Wallen, 1996).The generalizations of the findings of the study was limited because of the sample size. However, population validity was eliminated when the subjects having the same characteristics mentioned in the present study were generalized. Moreover, Fraenkel and Wallen (1996) stated that the ecological validity is the degree to which results of a study can be extended to other settings. In the present study, the treatments and tests were given in regular classroom settings. So, the results of the present study can be generalized to classrooms settings similar to this study.

3.11 The Assumptions and Limitations

In this section, assumptions and limitations of the present study are discussed.

3.11.1 Assumptions

It is assumed that the subjects were able to understand and interpret the items truly. Besides, it is also assumed that all participants answered the GAT accurately and sincerely. Moreover, it is assumed that participants give answers honestly to interview questions. No outside event occurred during the experimental study to affect the results. Also, the instruction given two classes was considered equal. Moreover, the administration of the test (GAT) and questionnaire were completed under standard conditions. The teacher is the researcher in this study; it was assumed that it did not affect the results of the study.

3.11.2 Limitations

The nature of this study is limited to the data collected from 32 students studying at 2 different classes in one private school in Ankara, whereas there are about 2 million fourth grade students in Turkey. Therefore the study can not be generalized to all fourth grade elementary students.

The inexperience of the researcher on the techniques of interviewing could be another limitation. Moreover, since there was no control group in the study, it can not be proved that instructions with concrete materials do not make positive changes among students' GAT scores.

CHAPTER IV

RESULTS OF THE STUDY

The theoretical background of the study, the review of the previous studies and the method of the present study were stated in the previous chapters. The result of this study is explained in three different sections. The first section presents the results of the descriptive statistics. The second section is the results of the inferential statistics section where the results of the testing hypotheses associated to the problems are included. Finally, the last section presents the summary of results.

4.1 The Results of Descriptive Statistics

In this section the descriptive statistics of the data are given. Descriptive statistics were used to classify and summarize numerical data. Table 4.1 shows the means and standard deviations, the number of participants and the minimum/maximum values of the variables.

Table 4.1 Mean, Standart Deviation, Number of Participants, Maximum and Minimum Values of GAT

Time	Mean	Std. Deviation	N	Minimum Value	Maximum value
Pre-intervention	38.281	10.66	32	7	64
Post-intervention	58.469	14.79316	32	26	77
Follow-up	55.844	14.74320	32	26	89

As it is seen in Table 4.1, mean of GAT scores at post-intervention is higher than mean of GAT scores at pre-intervention and follow-up ($M_{postint}$ = 58.47 , $SD_{postint}$ = 14.79 ; M_{preint} = 38.28 , SD_{preint} = 14.79 ; $M_{followup}$ = 55.84 , $SD_{followup}$ = 14.74). However, mean scores of students at follow-up are lower than post-intervention but higher than pre-intervention. In addition, the post–intervention and follow up geometry achievement scores were very close to each other. Furthermore, there was slightly decrease in the follow-up test score. However, the minimum value of the post-intervention and follow-up is equal and much higher than the minimum value of pre-intervention ($Min_{postint} = 26$; $Min_{followup} = 26$; $Min_{preint} = 7$). The maximum value of follow – up is higher than the post – intervention's maximum value which is higher than the maximum value of pre-intervention ($Max_{followup} = 89$; $Max_{postint} = 77$; $Min_{preint} = 64$).

The following figure shows the mean scores of GAT across three time periods.

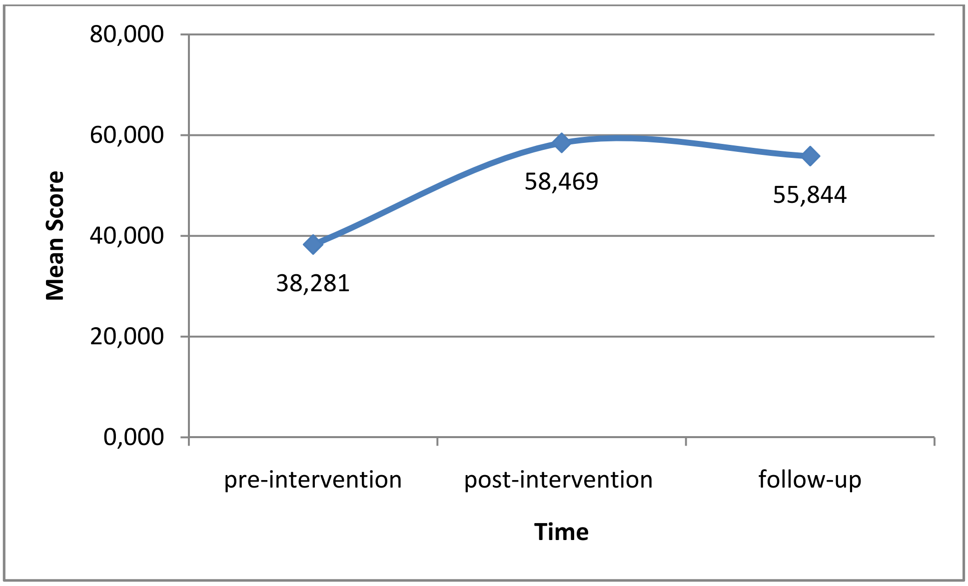


Figure 3.9 GAT Mean Scores across Three Time Periods

According to Figure 3.9, it was easily seen that pre-intervention has the minimum mean score of the present study as 38.281. If the student gives correct answers to the GAT, they will take maximum score as 80. So, the achievement percentage of post-intervention is calculated as 48%. Post-intervention which has a minimum achievement percentage has 73%. Also, the achievement percentage of follow-up is 70% which is very close to the achievement percentage of post-intervention.

The following figures show the distribution of the students' geometry achievement scores across pre-intervention, post-intervention and follow-up.

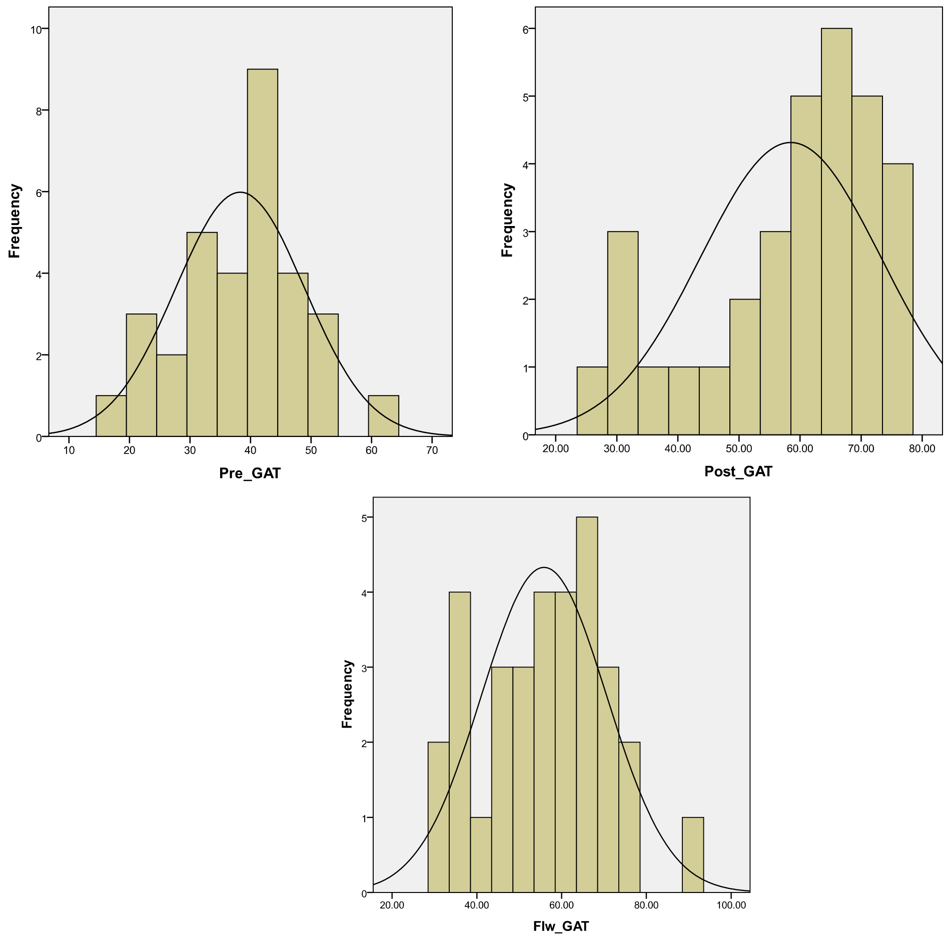


Figure 3.10 Distributions of Geometry Achievement Scores across Pre-intervention, Post-intervention and Follow-up

According to Figure 3.10, in pre-intervention GAT scores, approximately half of the students got scores above the average (M_{preint} = 38.28). Besides, the number of students who got the scores above average are higher than the number of students who got the scores below average in post-intervention ($M_{postint} = 58.47$) and follow-up ($M_{followup} = 55.84$).

4.2. The Result of Inferential Statistics

In this section, the sub-problems of the study will be examined by means of their associated hypotheses which are in the null form and tested at a significance level of 0.05.

4.2.1 The Results of the First Main Problem

The First Main Problem P1: What is the effect of instruction with concrete materials on fourth grade students' geometry achievement?

The following hypothesis is stated for main problem;

Hypothesis: There is no statistically significant change in 4^{th} grade students' geometry achievement across three time periods (Pre-intervention, post-intervention, and follow-up).

To test this hypothesis, one-way repeated measures ANOVA is used. One of the main assumptions is the normality assumption. The normality assumption for SAT is determined by Kolmogorov-Smirnov statistics.

Before conducting the analysis, assumptions on the use of simple repeated – measures ANOVA stated by Hinkle, Wiersma and Jurs (2003) were checked. Several assumptions underlie the use of simple repeated-measures ANOVA.

One of the main assumptions is the normality assumption. The normality assumption for GAT is determined by Kolmogorov-Smirnov statistics. To check normal distribution of the gain scores, Kolmogorov-Simirnov statistics was run. Table 4.2.1 presents the test of normality results.

Table 4.2.1 Results of Kolmogorov-Simirnov Test

	Statistic	df	Sig.	Skewness	Kurtosis
Post-pre intervention Gain Score	0.121	32	0.200*	-0, 798	0.445
Follow up-pre intervention Gain Score	0.072	32	0.200*	-0.019	-0.938
Follow up-post intervention Gain Score	0.194	32	0.004	1.298	4.119

*>0.05

As shown in Table 4.2.1. according to Kolmogorov-Smirnov statistics the normality assumptions were both satisfied for the gained score for post - pre intervention ($p>0.05$) and follow up – preintervention ($p>0.05$). The skewness and kurtosis of the values were between +2 and -2 so that it could be accepted as normally distributed according to criteria stated by (George & Mallery, 2003). Moreover, to verify the normality assumption the histograms and normal Q-Q Plot were drawn. They were given below in figure 3.11 and 3.12.

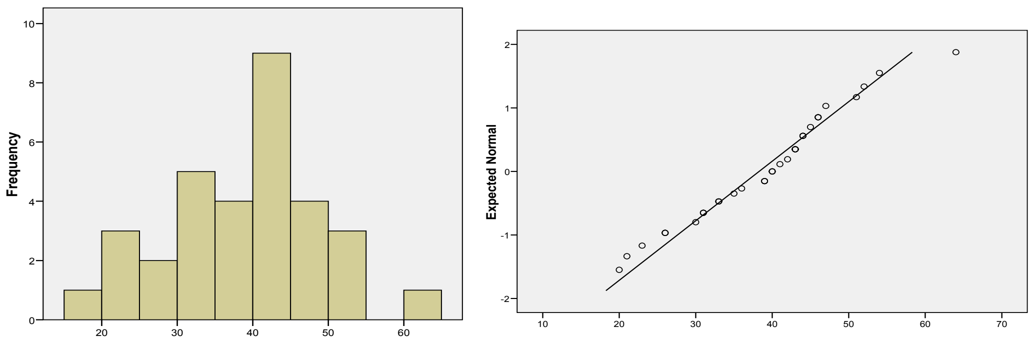


Figure 3.11 Histogram and Normal Q-Q Plot of the Gained Scores for Pre-Intervention and Post-Intervention

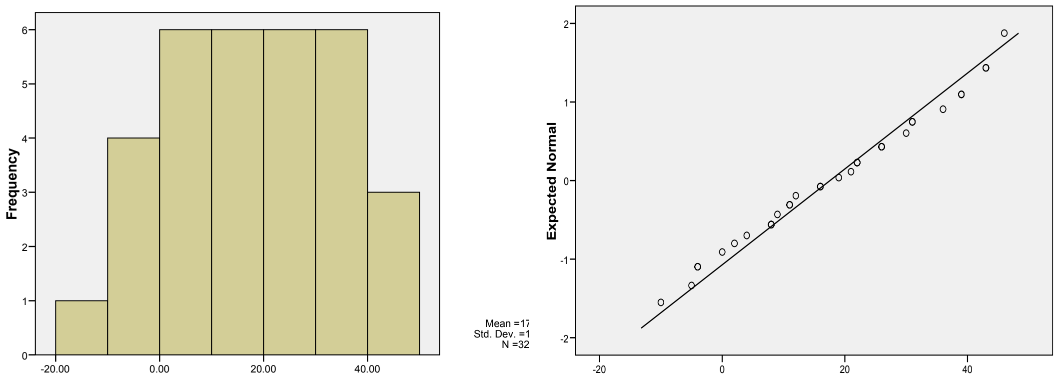


Figure 3.12 Histogram and Normal Q-Q Plot of the Gained Scores for Pre-Intervention and Follow-Up

As seen in Figure 3.11 and 3.12, both histograms had almost normal distribution. In additon, in the normal Q-Q Plots of gained scores for pre - post intervention and pre - intervention – follow up, the lines were almost straight so the normality assumption was shown according to the guideline stated by George (2001) if the distribution is normal, then a straight diagonal line running from the lower left corner to the upper right corner will appear. Also, some scores were not fall along the straight line which can indicate outliers and possible deviation from normality.

On the other hand, as shown in Table 4.2.1 according to Kolmogorov-Smirnov statistics the normality assumption did not seem to be satisfactory for the gained score of follow-up and post-intervention since ($p<0.05$). Also, the skewwness and kurtosis values were not between +2 and -2 so that it could not be accepted as normally distributed according to criteria stated by (George & Mallery, 2003). However, according to the Central Limit Theorem, the distribution can be taken as normal for any sample size greater than or equal to 30 (Gravetter&Wallnau, 2004). So, depending on central limit theorem the distribution can be accepted as normal. In order to verify the normality assumption the histograms and normal Q-Q Plot were drawn. They were given below.

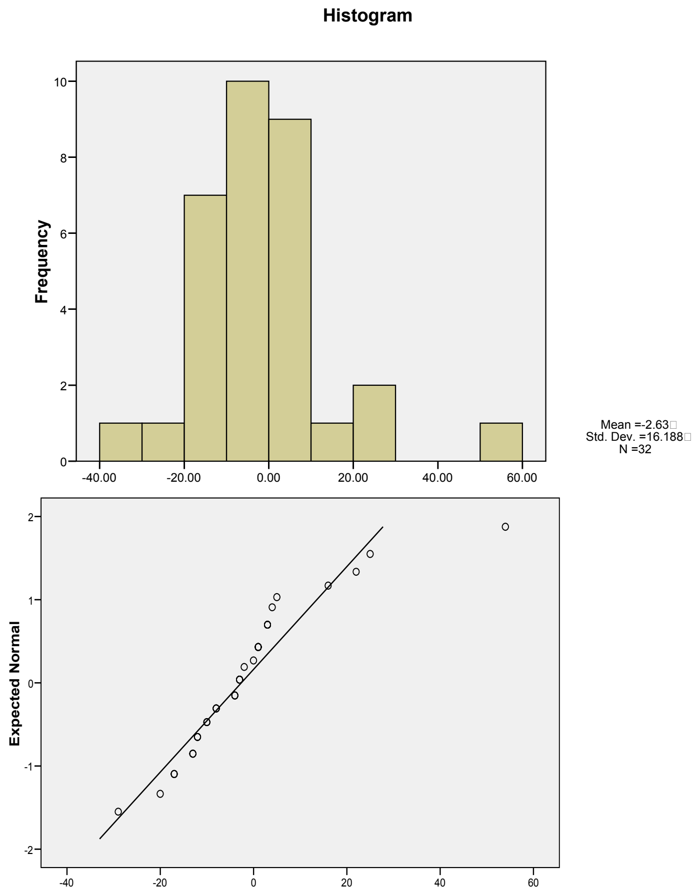


Figure 3.13 Histogram and Normal Q-Q Plot of the Gained Scores for Follow-up and Post-intervention

Another assumption was related to the sphericity. It was tested by using the Mauchly's Test of Sphericity. Its results were given in Table 4.2.2.

Table 4.2.2 Results of Mauchly's Test of Sphericity for the GAT Scores

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
Time	0.998	0.056	2	0.973

As seen in Table 4.2.2 the sphericity assumption was satisfied (p>0.05).

Therefore to test hypothesis, one-way repeated measures ANOVA was performed. The hypothesis was tested at 0.017 by (0.05/3), significance level because there were measurements at three time periods according to guidelines stated by (Colman & Pulford, 2006).

To test hypothesis, one-way repeated measures ANOVA was performed. Then, the results of one-way repeated measures ANOVA for GAT scores with respect to time was examined. The results values related to Wilk's Lambda is given in Table 4.2.3.

Table 4.2.3 The Values Related to Wilk's Lambda

Effect	Value	F	Sig.	Partial Eta Squared	Observed Power
Wilks' lambda	0.361	26539	0.000	0.639	1.000

As seen in Table 4.2.3, it was found that there was a statistically significant change in 4^{th} grade students' geometry achievement across three time periods (Wilks' lambda=0.361, F=26.539, p=0.000). The partial eta-squared was found as 0.689. This result suggested very large effect size by utilizing guidelines proposed by Cohen (1988).

In order to find out which pairs of time periods (pre-intervention, post-intervention, and follow up) caused the mean difference, the Bonferroni test was used. The results were given in Table 4.2.4.

Table 4.2.4 Pairwise Comparisons of GAT Scores of Students

(I)time	(J)time	Mean Difference (I-J)	Sig.
Pre	Post	-20.188	0.000
	Follow up	-17.563	0.000
Post	Follow up	2.625	1.000

According to Table 4.2.4., it was found that there was a statistically significant change in 4^{th} grade students' geometry achievement between the pre and post interventions (p<0.017). In other words, the mean score of pre–intervention GAT scores was lower than the mean score of post-intervention GAT scores ($M = 38.28$, SD_{preint} = 14.79 ; $M = 58.47$, $SD_{postint}$ = 14.79). It was also found that the statistically significant change was observed in students' achievement test scores between the pre-intervention and follow-up as well, (p<0.017). Also, the mean score of pre-intervention GAT scores was lower than the mean score of follow – up GAT scores ($M = 38.28$, SD_{preint}= 14.79; $M = 55.84$, $SD_{followup}$= 14.74). On the other hand, there was no statistically significant change in 4^{th} grade students' geometry achievement between the post-intervention and follow-up (p>0.017). Similarly, the mean scores of both post-intervention and follow-up were precise ($M = 58.47$, $SD_{postint}$= 14.79 ; $M = 55.84$, $SD_{followup}$= 14.74).

4.2.2 The Results of the Second Main Problem

The Second Main Problem P2: What are the fourth grade students' opinions and feelings about instruction with concrete materials?

According to the answers for the first part of the interview questions, such a theme, "Students' feelings and opinions towards mathematics" was emerged. The table of this theme is given below.

Table 4.3.2 Students' Feelings and Opinions towards Mathematics

Students' opinions about Mathematics	**Number of students (%)**
I do not like Math before but my teacher caused me to love this lesson.	6 (55)
I like both art and geometry very much since they are similar in drawing.	5 (45)
When I think of math lesson, daily life mathematical problems come to my mind.	9 (82)

Table 4.3.2, in the first part of the interview questions which were decided to get students' opinions and feelings towards mathematics, more than half of the students said that they did not like mathematics before but their teacher caused them to love this lesson. Moreover, daily life mathematical problems came to the almost all of the students minds, when they think about math.

The second part of the interview includes questions to have opinion and feelings about instructions with concrete materials. Students' answers were categorized as "enjoyment", "anxiety", "easiness", "usefulness", "fondness" and "relations with other courses".

According to the students' answers for the interview questions, such a theme, “Students’ feelings and opinions related with enjoyment” was emerged. The table of this theme is shown below.

Table 4.3.3 Students’ Feelings/Opinions related with Enjoyment

Answer categories	**Students' explanations**	**Number of students (%)**
	I both enjoy and learn together since concrete materials were used.	7 (63)
	This year I am not sleepy in Math lessons because I used variety of concrete materials.	1 (9)
enjoyment	My interest in the lesson has increased as I used concrete materials.	3 (27)
	I feel more confident while using concrete materials.	2 (18)
	I feel happy while using concrete materials.	8 (73)

As seen in Table 4.3.3, more than half of the students said that they both enjoy and learn together in which concrete materials were used.

According to the students’ answers for the interview questions, such a theme, “Students’ feelings and opinions related with anxiety” was emerged. The table of this theme is shown below.

Table 4.3.4 Students’ Feelings/Opinions related with Anxiety

Answer categories	Students' explanations	Number of students (%)
anxiety	I become anxious when I first see the questions before using concrete materials.	3 (27)
	I feel myself comfortable while using concrete materials and I also do not feel any anxious whether I can use them or not.	1 (9)

As seen in table 4.3.4, three out of 11 students feel anxious when they first see the questions before using concrete materials.

According to the students' answers for the interview questions, such a theme, "Students' feelings and opinions related with easiness" was emerged. The table of this theme is shown below.

Table 4.3.5 Students' Feelings/Opinions related with Easiness

Answer categories	Students' explanations	Number of students (%)
Easiness	The lessons in which I used concrete materials are easier to understand than the other lessons.	2 (18)
	The questions seem to be hard before I used concrete materials.	10 (91)
	When I saw the questions after using the concrete materials, they were easier.	10 (91)

Table 4.3.5 (continued)

Answer categories	Students' explanations	Number of students (%)
	I understand the subject more while using concrete materials since the subjects become more concrete.	9 (82)
	While answering the questions, the activities come to my mind and then questions become easy.	4 (36)

As seen in Table 4.3.5, the number of those students was almost the same as the number of students who found the questions easy after using the concrete materials. Moreover, four out of 11 students stated that "The activities come to my mind and then questions become easy."

According to the students' answers for the interview questions, such a theme, "Students' feelings and opinions related with usefullness" was emerged. The table of this theme is shown below.

Table 4.3.6 Students' feelings/opinions related with usefulness

Answer categories	Students' explanations	Number of students (%)
Usefulness	The protractor is most useful because it is very easy to measure the angles with it.	1 (9)
	The geoboard is most useful because it becomes easy to find perimeter and area of the shapes.	3 (27)
	The symmetry mirror is most useful because it becomes easy to draw the symmetry of the given shapes.	1 (9)
	The cubes are most useful because while constructing shapes counting the number of shapes become easier.	4 (36)

Table 4.3.6 (continued)

Answer categories	Students' explanations	Number of Students (%)
	The pattern blocks are most useful because by using them I feel myself making 3D modeling.	1 (9)
	The mason ruler is most useful. I remembered many properties of the shapes because it is easy to make the shapes with that material.	1 (9)
	The pipes are the most useful because making square, rectangle and triangle with pipes is easy.	1 (9)

As seen in Table 4.3.6, the concrete material that was the most useful was cubes since students feel themselves making 3D modeling while using cubes.

According to the students' answers for the interview questions, such a theme, "Students' feelings and opinions related with fondness" was emerged. The table of this theme is shown below.

Table 4.3.7 Students' feelings/opinions related with fondness

Answer categories	Students' explanations	Number of students (%)
Fondness	I like the protractor most because I feel myself very good while measuring.	1 (9)
	I like the geoboard most because it is enjoyable to make shapes with rubber.	4 (36)
	I like the symmetry mirror most because I like its color.	1 (9)

Table 4.3.7 (continued)

Answer categories	Students' explanations	Number of students (%)
	I like the symmetry mirror most because it is different from the other mirrors I had ever seen.	1 (9)
	I like the cubes most because I like 3D modeling.	2 (18)
	I like the pattern blocks most because symmetric tessellation appears good.	1 (9)
	I like the mason ruler because it is very enjoyable tool.	1 (9)

As seen in table 4.3.7, the concrete material that was liked most was the geoboard. It may be because of students enjoyed making shapes using rubbers.

According to the students' answers for the interview questions, such a theme, "Students' feelings and opinions related with other courses" was emerged. The table of this theme is shown below.

Table 4.3.8 Students' Feelings/Opinions related with Relations with other courses

As shown in Table 4.3.8, the concrete material that was liked most by 4 out

Answer categories	Students' explanations	Number of students (%)
Relations with other courses	I make a relation with geometry and art during performing activities with concrete materials.	4 (36)
	I make a relation with geometry and Science during performing activities with concrete materials.	2 (18)
	I make a relation with geometry and Turkish lessons during performing activities with concrete materials. Since some of the symbols are similar with geometric shapes.	1 (9)
	I could not make a relation with other courses.	4 (36)

of 11 students is geoboard. Most of the students could either relate geometry to art or could not make relation with any other course. The number of students who made the art relation was equal with those not able to find a relation.

CHAPTER 5

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

This chapter includes interpretation of the results, conclusion of the study and some recommendations for further studies. In the first section, discussion of the result is given. In the second section conclusions are drawn and in the last section some recommendations for further research studies are made.

5.1 Discussion of Findings

In this section the findings related to students'geometry achievement and and their opinions and feelings about the instruction are dicussed.

5.1.1 Discussion on Geometry Achievement

The present study has two main problems. The first main problem of this study was to investigate the effectiveness of concrete materials on fourth grade students' geometry achievement. To test the effects of concrete materials, oneway repeated measures ANOVA was used. In the present study it was found that there was a statistically significant change in geometry achievement of fourth grade students who participated in the instruction with concrete materials over three time periods. In other words, there were statistically significant positive changes in students' geometry achievement across pre-intervention and post-intervention and across pre-intervention and follow-up. In other words, the mean score of post-intervention was higher than the mean score of pre-intervention. The mean score of follow-up was also higher than the mean score of pre-intervention. Moreover, there was no statistically significant change in students' achievement across post-intervention and follow-up.

The analysis of the present study shows that students' academic performance has increased after the pre-intervention; this is in line with the results of Suydam and Higgins (1976), Bayram (2004), Stigler (1990), Ross (2004), Sowell (1989) and Allen (2007). One of the factors for this increase in performance could be concrete development level. According to Piaget (1973), the concrete operational stage is the basis for the use of manipulatives. The concrete operational stage begins at seven and goes to age twelve. The age of the students in the study ranged from 9 years of age to 10 years of age. These students are in the concrete operational stage, so manipulatives are still effective thus they increase students' achievement scores. The other factors can be active involvement of the students during the instruction and the utilization of concrete materials as stated by Bruner (1966), Piaget (1973), Dienes (1971) and Ross (2004). The last factor can be related to the students'positive affective characteristics, such as attitude towards geometry and ICM. In this point of view, Allen (2007) found out the enjoyment the students had as they worked with manipulatives. Another factor that may have played a major role in the results of the study is the students' eagerness to use concrete materials. This is consistent with the study of Garrity (1998) while contradicting the findings of Thomas (1975). Yet another factor that could be responsible for the result of the study is the fact that students' understandings move from concrete to the abstract level by using manipulatives. Hartshorn and Boren (1990) made a similar explanation.

In the present study, the mean score of follow-up was slightly lower than the mean scores of post-intervention. However, there is no significant mean difference between these scores. This finding was very impressive because the retention of the knowledge was satisfied in spite of summer break. Sowell (1989) stated that concrete materials have positive effects on students' geometry achievement but after time period their achievement can decrease. The reason for this decrease in performance could be, as Sowell (1989) found out that the shortterm treatment with manipulatives. The treatment took only 10 weeks in this study.

In spite of generally positive results like in the present study, there have been inconsistencies in some research findings. For example, in studies by Resnick and

Omanson and by Labinowicz, the use of base-ten blocks showed little impact on children's learning. In contrast, Fuson and Briars (1990) reported positive results from the use of base-ten blocks. Also, some researchers concluded that there was a trend the score of students who did not use materials became higher than the students' score who used materials (Suydam&Higgins, 1976; Allen, 2007). Post (1981) argued that the differences in results among these studies might be due to the nature of the students' engagement with the concrete materials. "In general, however, the ambiguities in some of the research findings do not undermine the general consensus that concrete materials are valuable instructional tools" (Post, 1981 p.27)

5.1.2. Discussion on Students' Opinions and Feelings about the Instruction

The second main problem was to investigate the fourth grade students' opinions and feelings about instruction with concrete materials. In order to test this problem, 11 fourth grade students were interviewed. Students' answers were categorized as "enjoyment", "anxiety", "easiness", "usefulness", "fondness" and "relations with other courses". The reason for the results of the second main problem is similar with the reasons for the results of the first main problem.

The "enjoyment" category which was constructed by the answers to question number 10 shows 63% of the students were enjoyed and learned together when concrete materials were used. This result is consistent with the opinions of Allen (2007), Battle (2007), Bayrak (2008), Ross (2004) and Bayram (2004). They argued that participants showed more interest and enjoyment when learning was done through the use of manipulatives. Moreover, 8 out of 11 students stated their happiness while using concrete materials.

According to students' answers on question number 4, answers were categorized as "anxiety". In this category, only 27 % of the students stated that they became anxious when they first saw the questions before using concrete materials.

Since students' first encounter with GAT before ICM in pre-intervention, this is not an unexpected result. Any time a student is faced with questions regarding an area he hasn't learnt yet, he become anxious.

In the "easiness" category, almost all students stated that "The questions seem to be hard before I used concrete material" and "When I saw the questions after using the concrete materials, they become easier". Students' understanding of basic math skills increases while using manipulatives (Allen, 2007). So, students can solve problems easier. In addition 82% of the students stated that they understood the subject more while using concrete materials since the subjects become more concrete.

According to students' answers on question number 8, answers were categorized as "usefulness". Students were asked "*Which one of the concrete materials was useful for you? Why?*" Their answers varied from each other. 4 of the students stated that "The cubes are most useful because while constructing shapes counting the number of cubes become easier." and 3 out of 11 students found the geoboard useful because it becomes easy to find perimeter and area of the shapes.

In the "fondness" category, similar to the answers for usefulness category, 4 out of 11 students like geoboard more than the other concrete materials. However, these are not the same students who find the geoboard more usefull. During ICM, most of the students seemed to like the mason ruler most but the actual results showed that only 1 out of 11 students like the mason ruler. Moreover, similar to the findings in "usefulness" category, the other material that the students like was cubes. As a summary, the most usefull materials and the most like materials were same.

According to students' answers on question number 11, answers were categorized as "relations with other courses". The result showed the number of students who made the art relation was equal to those not able to find a relation. There was an interesting answer and explanation to the question number 11. One of the interviewed students makes a relation with geometry and Turkish lessons. The explanation of the student was that some of the punctuation symbols in Turkish language are similar with geometric shapes such as the exclamation mark. The exclamation mark was said to be constructed with a rectangle and a square.

5.2 Conclusions of the Study

In the light of the findings stated in the previous chapter obtained by examining hypotheses the following conclusions can be deduced:

It was found that 4^{th} grade students' geometry achievement scores increased across pre-intervention and post-intervention. Similarly, students' geometry achievement scores increased across pre-intervention and follow-up. This shows that, geometry instruction using concrete materials has a positive effect on students' academic achievement across pre-post intervention and pre intervention-follow up. Moreover, it was found that there was a small decrease between the post-intervention and the follow-up despite the summer break of three months. That means that instructions with concrete materials help to reach a degree of persistence in knowledge.

Interview findings show that,

- In the enjoyment category, most of the students feel happier in those classes where concrete materials are used.
- In the anxiety category, some of the students became anxious when they first saw the questions in pre-intervention.
- In the easiness category, most of the students stated that questions become easier after ICM.
- In the usefulness category, cubes and the geoboard were the most useful as perceived by the students.
- In the fondness category, cubes and the geoboard were the most liked by students.

5.3 Recommendation

In this section recommendations are stated for teachers, curriculum developers, teacher educators and researchers for the purpose of future studies in the use of manipulatives in the classroom.

Teachers

Usage of concrete materials needs patience. Teacher should be patient while teaching how to use concrete materials. In this study, many activities with different kinds of manipulatives were used; it is recommended in the further studies that the number of activities involving the use of and the varience in concrete materials should be increased. Another important point that teachers should be careful is the cognitive level of the students. This study was applied with fourth grade elementary level students and activities were selected with respect to their cognitive level, it is suggested that selection of the activities should be appropriate with students'cognitive level. To maximize the effect of the teacher's help to a child, it is also important to realize how the cognitive systems develop or, in other words, when a child is ready to learn (Bayram, 2004). Another suggestion that could be drawn from the study is that interviews performed with students would provide beneficial information about students' feelings and their opinions. Knowing students feelings and opinions about using concrete materials is very helpful for preparing activities for further studies. These activities may involve concrete materials such as students' like most and find useful.

Teacher educators

Effective usage of concrete materials is not easy. Teachers should have enough experiences and knowledge about using them. Different teacher training strategies needed for the effective use of concrete materials. For example, different courses on “How and when to use different types of concrete materials in mathematics or geometry” can be given in the universities for preservice teachers.

Recommendation for further studies:

This study was conducted with a private school student in Cankaya, districts of Ankara. Additional research using public elementary schools in other locations or cities, sample sizes and participants are recommended. In addition, this study was performed with fourth grade elementary school students; research on students in other grades is also suggested. Interviews in the current research performed with only 11 students. In the further research, the number of students who performed interview can be increased. In this study, the effects of concrete materials on students’ geometry achievement were examined. In the further studies, concrete materials’ effect on both achievement and attitude changes could be investigated.

REFERENCES

Allen, C. (2007). An action based research study on how using manipulatives will increase students' achievement in Mathematics. *Master's Program Action Research Project.*, Marygrove College.

Altun, S. A. & Çakan M. (2008). Öğrencilerin Sınav Başarılarına Etki Eden Faktörler: LGS/ÖSS Sınavlarındaki Başarılı İller Örneğ. *İlköğretim Online, 7* (1), 157-173.

Baines L. A. & Slutsky R. (2009). Developing the Sixth Sense: Play. *Educational Horizons*, *87*(2), 97-101

Baki, A. (2001). Bilişim Teknolojisi Işığı Altında Matematik Eğitiminin Değerlendirilmesi. *Milli Eğitim Dergisi,* 149, 26-31.

Battle, T.S. (2007). Infusing Math Manipulatives: The Key to an Increase in Academic Achievement in the Mathematics Classroom. Final Research Proposal.

Bayrak, M.E. (2008). *Investigation of effect of visual treatment on elementary school student's spatial ability and attitude toward spatial ability problems.* Unpublished master's thesis. Middle East Technical University, Ankara.

Bayram, S. (2004). *The effect of instruction with concrete models on eighth grade students' geometry achievement and attitudes toward geometry.* Unpublished master's thesis. Middle East Technical University, Ankara.

Berberoğlu, G., Çelebi. O., Özdemir, E., Uysal, E., & Yayan, B. (2003). Factors affecting achievement levels of Turkish students in the Third International Mathematics and Science Study (TIMSS). *Educational Sciences and Practice*, 2(3), 3-14.

Bloom, B.S., (1976). *Human Characteristics and School Learning*, McGraw-Hill Book Company, New York.

Bonwell, C. C. & Sutherland, T. E. (1996). The Active Learning Continuum: Choosing actvities to engage students in the classroom. *New Directions for Teaching and Learning, 67, 3-15.*

Boyd, B. A. (1992). The relationship between mathematics subject matter knowledge and instruction: A case study. Department of Mathematical Sciences, San Diego State University.

Brown, S.K. (2006). Making the connections: Manipulatives in mathematics. Action Research Project, Marygrove College. 1-21.

Bruner, J. S. (1966). *Toward a theory of instruction*. Cambridge, Mass.: Harvard University Press. In R. C. Sprinthall, & N. A. Sprinthall (1977. *Educational Psychology:* USA. *A Developmental Approach*. Addison-Wesley Pub.Comp. USA.

Bruner, J. S. (1974). *Educatioanal Psychology: A developmental Approach*. Cambridge, Mass.: Harvard University Press. In Sprinthall, R. C., & Sprinthall, N. A. (1977). *Educational Psychology: A Developmental Approach*. Addison-Wesley Pub. Comp., USA.

Burger, W. & S Burger, W. F. & Shaughnessy, M. (1986). Characterizing the van Hiele Levels of Development in Geometry. *Journal for Research in*

Mathematics Education, *17*(1), 31-48.

Burns, M., & Silbey, R. (2000). *So you have to teach math? Sound advice for K-6 teachers.* Sausalito, CA: Math Solutions Publications.

Canny, M. E. (1984). The relationship of manipulative materials to achievement in three areas of Fourth-Grade mathematics: computation, concept development, and problem solving. *Dissertation Abstracts Internationa,* 45 (A), 775-76.

Caine, R. N. & G. Caine (1991). *Making Connections: Teaching and the Human Brain.* Menlo Park, CA: Addison-Wesley Publishing Company.

Chanlin, L.J. (1999). Visual Treatment for Different Prior Knowledge. *International Journal of Instructional Media*, *26*(2), 213-219.

Choi-Koh, S. S. (1999). A student's learning of geometry using computer. *The Journal of Educational Research, 92*(5), 301-311.

Clements, D. H. & Battista, M. T. (1992). Geometry and Spatial Understanding. In Dougles A. Grouws (Ed.,), Handbook of Research Mathematics Teaching and Learning. New York. McMillan Publishing Company.

Clements, D. H. (1999). Concrete manipulatives, concrete ideas. *Contemporary Issues in Early Childhood*, *1*(1)*,* 45-60.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences.* Hillside, New Jersey: Erlbaum.

Colman, A., & Pulford, B. (2006). *A crash course in Spss for windows updated for versions 10,11,12, and 13*. (3rd ed.). Oxford: Blackweell.

Copland, R. W. (1984). How children learn mathematics. (4th ed.). New York: MaCMillan Publishing Company.

Çakıroğlu, E., Yıldız, B., T. (2007). Turkish Pre-service Teachers' Views about Manipulative Use in Mathematics Teaching: The Role of Field Edxperience and Methods Course, In C. V. Sunal and K. Mutua (Eds) *The Enterprise of Education*, (pp. 275-289) Charlotte, NC: Information Age Publishing.

Çakıroğlu, E., Yıldız, B., T. (2007). Turkish Pre-service Teachers' Views about Manipulative Use in Mathematics Teaching: The Role of Field Edxperience and Methods Course, In C. V. Sunal and K. Mutua (Eds) *The Enterprise of Education*, (pp. 275-289) Charlotte, NC: Information Age Publishing.

Dienes, Z. P. (1971). An Example of the Passage from the Concrete to the Manipulation of Formal Systems. *Educational Studies in Mathematics*, *3*(3/4), 337-352.

Durmuş, S., Toluk, Z., & Olkun, S. (2002). *Sınıf öğretmenliği ve matematik öğretmenliği öğrencilerinin geometrik düşünme düzeyleri.* Orta Doğu Teknik Üniversitesi'nce düzenlenen 5.Ulusal Fen Bilimleri ve Matematik eğitimi Kongresi'nde sunulmuş bildiri, 16-18 Eylül: ODTÜ, Ankara.

Elswick, V. A. (1995). Using manipulatives to develop understanding. *In Integrated mathematics 1, Teachers Edition*. Boston: Houghton Mifflin Company.

Erdoğan, T. (2006). *Van Hiele modeline dayalı öğretim sürecinin sınıf öğretmenliği öğretmen adaylarının yeni geometri konularına yönelik hazırbulunuşluk düzeylerine etkisi.* Yayımlanmamış yüksek lisans tezi, Abant İzzet Baysal Üniversitesi, Bolu.

Fraenkel, J. R. & Wallen, N. E. (2003). How to design and evaluate research in education, (6^{th} ed.). New York: McGraw-Hill, Inc.

Frankel, J. R. & Wallen, N. E., (1996). *How to Design and Evaluate Research in Education*, New York: Mc Graw-Hill, Inc.

Fuys, D., Geddes, D. & Tischler, R. (1988). *The Van Hiele model of thinking in geometry among adolescents*. Reston, VA: National Council of Teachers of Mathematics.

Garrity, C. (1998). Does the Use of Hands-On Learning, with Manipulatives, Improve The Test Scores of Secondary Education Geometry Students. *Master's Program Action Research Project. St. Xavier University.*

Gibson, J.J. (1962). Observations on active touch. *Psychological Review, 69*(6), 477-491.

Durmus, S. & Karakırık, E. (2006). Virtual manipulatives in mathematics education: A Theoretical Framework. *The Turkish Online Journal of Educational Technology, 5*(1), 117-123.

Eggen, P. D. & Kauchak, D. P. (2000). *Educational psychology:Windows on classrooms* (5th ed.). Upper Saddle River, NJ: Prentice Hall.

Erdogan, T., Akkaya, R. & Akkaya, S. (2009). The effect of the van hiele model based instruction on the creative thinking levels of 6th grade primary school students. *Educational Sciences: Theory and Practice*, *9*(1), 181-194.

Fielder, D. R. (1989). Project hands-on math: Making a difference in K-2 classrooms. *Arithmetic Teacher*, *36*(8), 14-16.

Fuson, K.C. & Briars, D.J. (1990). Using a base-ten blocks learning/teaching approach for first- and second-grade place-value and multidigit addition and subtraction. *Journal for research in mathematics education, 21*(3), 180–206.

George, C.A (2001, February). *Evaluating Assumptions of Multivariate Normality.* Paper presented at the Annual Meeting of the Southwest Educational Research Association, New Orleans, Los Angeles.

George, D. & Mallery, P. (2003).SPSS for Windows Step by Ste,.(4th ed.). Pearson Education, Inc.

Gilbert, R., & Bush, W. (1988). Familiarity, availability, and use of manipulative devices in mathematics at the primary level. *School Science and Mathematics*, *88*(6), 459-469.

Goos, M., & Spencer, T. (2003). Properties of shape, mathematics-making waves. In Goos, M., & Spencer T. (Eds.) *Proceedings of the Nineteenth Biennial Conference of the Australian Association of Mathematics Teachers* (pp. 424-434). Inc. Adelaide: AAMT Inc.

Gravetter, F.J., & Wallnau, L.B. (2004). *Statistics for the behavioral sciences*. (6^{th} ed.). Belmont, CA: Thomson Learning, Inc.

Gutierrez, A., Jaime, A., & Fortuny, J. (1991). An alternative paradigm to evaluate the acquisition of the van Hiele levels. *Journal for Research in Mathematics Education*, *22*(3), 237-251.

Hartshorn, R., & Boren, S. (1990). Experimental learning of mathematics: Using manipulatives. *ERIC Digest.* (ED 321967).

Haury, D. L. & Rillero, P. (1994). Perspectives of Hands-On Science Teaching. Columbus: ERIC Publications

Heddens, J. W. (1986). Bridging the gap between the concrete and the abstract. *Arithmetic Teacher*, *33*(6), 14-17.

Heddens, J. W. (1997). Improving Mathematics Teaching by Using Manipulatives. Retrieved October 2, 2007, from Kent State Universtiy Website: http://www.fed.cuhk.edu.hk/~fllee/mathfor/edumath/9706/13hedden.html.

Heddens, J. W. (2005). *Improving Mathematics Teaching by Using Manipulative*s. Retrieved January 1, 2010, from http://www.fed.cuhk.edu.hk/~fllee/mathfor/edumath/9706/13hedden.html

Howden, H. (1986). The role of manipulatives in learning mathematics. *Insights into Open Education*, 19(1), 1-11.

Hynes, M. (1986). Selection criteria. *Arithmetic Teacher*, 33 (6), 11-13.

Kılıç, Ç. (2003). İlköğretim 5. sınıf matematik dersinde Van Hiele düzeylerine göre yapılan geometri öğretiminin öğrencilerin akademik başarıları, tutumları ve hatırda tutma düzeyleri üzerindeki etkisi. Unpublished master's thesis, Anadolu University, Eskişehir.

Kilpatrick, J. & Nesher, P. (1990). *Mathematics and cognition: A research Synthesis by the International Group for the Psychology of Mathematics Education.* Cambridge: Cambridge University Press.

Kilpatrick, J. (1992). A history of research in mathematics education in D. Grouws, (ed.), Handbook of Research on Mathematics Teaching and Learning, Macmillan, New York, 3–38.

Knight, K. C. (2006). *An investigation into the change in the Van Hiele levels of understanding geometry of pre-service elementary and secondary mathematics teachers*. Unpublished master's thesis. The University of Maine, Orono.

Koehler, M.S., & Grouws, D.A. (1992). Mathematics teaching practices and their effects. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning: a project of the National Council of Teachers of Mathematics* (pp. 115-125). New York: Macmillan.

Mammana, C. & Villani, V. (1998). *Perspective on the Teaching of Geometry for the 21st Century*. Dordrecht: Kluwer.

Martino, A.M. & Maher, C. A. (1999). Teacher questioning to promote justification and generalization in mathematics: what research practice has taught us; *Journal Of Mathematical Behavior, 18*(1) 53-78.

Marton, F. (1981). Phenomenography - Describing Conceptions of the World Around Us, *Instructional Science*, 10(1981), 177-200.

MONE. (2004). *Talim ve Terbiye Kurulu Baskanlığı, İlkögretim Matematik Dersi (1-5. Sınıflar) Öğretim Programı.* (Board of Education, Elemenatry school mathematics curriculum (1-5th grades) Ankara: Milî Eğitim Bakanlığı.

MONE (2009). Eğitim Teknolojileri Genel Müdürlüğü. Retrieved March 4, 2010 from http://egitek.meb.gov.tr/Sinavlar/istatistik.html.

Mistretta, R. M. (2000). Enchancing geometric reasoning. *Adolescence*, 35(138), 365-379.

Metz, K. E. (1995). Reassessment of developmental constraints on children's science instruction, *Review of Educational Research*, *65*(2), 93-127.

Mitchelmore, M. C. (1997). Children's Informal Knowledge of Physical Angle Situations. *Cognition and Instruction*, *7*(1), 1-19.

Moch, P. (2001). Manipulatives Work. *Educational Forum,* 66 (1), 81-87. Retrieved October 20, 2006 from: http://www.findarticles.com/p/articles/mi_qa4013/is_200110/ai_n8975782

Moyer, S., P.(2001). Are we having fun yet? How teachers use manipulatives to teach mathematics. *Educational studies in mathematics*, *47*, 175-197.

McClung, L. W. (1998). *A Study on the Use of Manipulatives and Their Effects on Student Achievement in a High School Algebra I Class.* Master of Arts Thesis.
Salem- Teikyo University. 1-50

Mullis I. V. S., Martin M. O., Gonzales E. J., Gregory K. D., Garden R. A., O'Connor K.M., Chrostowski S. J., & Smith T. A. (2000). TIMSS 1999 International Mathematics Report: Findings from IEA's Repeat of the Third International Mathematics and Science Study at the Eighth Grade. Chestnut Hill, MA. Boston College.

National Advisory Committee on Mathematical Education. *Owerview and Analysis of School Mathematics Grades K-12*. Washington: Conference Board of the Mathematical Sciences, 1975.

National Council of Supervisors of Mathematics (1978). Position Statement on Basic Skills. *Mathematics Teacher*. *71*(2), 147-152.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: Author.

Ojose, B. (2008). Applying Piaget's Theory of Cognitive Development to Mathematics Instruction. *The Mathematics Educator*, *18*(1), 26–30

Olkun, S. & Toluk, Z. (2004). Teacher questioning with an appropriate manipulative may make a big difference [www.k-12prep.math.ttu.edub]. *IUMPST: The Journal, Vol 2 (Pedagogy).*

Olkun, S. (2003). Comparing computer versus concrete manipulatives in learning 2D geometry. Journal of Computers in Mathematics and Science Teaching, *22*(1), 43-56.

Piaget, J. (1977). *Epistemology and psychology of functions*. Dordrecht, Netherlands: D. Reidel Publishing Company.

Piaget, J. (1973). *Psychology of intelligence.* Totowa, New Jersey: Littlefield, Adams & Co., 119-155. In A. N. Boling (1991). They don't like math?Well, let's do something! *Arithmetic Teacher*, *38*(7), 17-19.

Perlman, C. L. (2003). *Practice tests and study guides: Do the help? Are they ethical? What is ethical test preparation practice?* ERIC Document Reproduction No. ED480062.

Pesen, C. (2003). *Matematik öğretimi.* Ankara: Nobel Yayın Dağıtım.

Philips, D.C & Soltis, J. F. (1985). *Perspectives on Learning*. (4th ed.). New York: Teachers College Press.

Post, T. (1981). The Role of Manipulative Materials in the Learning of Mathematical Concepts. In Selected Issues in Mathematics Education (pp. 109-131). Berkeley, CA: National Society for the Study of Education and National Council of Teachers of Mathematics, McCutchan Publishing Corporation.

Prescott, A., Mitchelmore, M., & White, P. (2002). Students' Difficulties in Abstracting Angle Concepts from Physical Activities with Concrete Material. In the Proceedings of the Annual Conference of the Mathematics Education Research Group of Australia Incorporated Eric Digest (ED 472950).

Resnick, L.B.; Omanson, S.F. 1987. *Learning to understand arithmetic*. *In:* Glaser, R., ed. *Advance in instructional psychology*, (vol.3, pp. 41–95). Hillsdale, NJ, Lawrence Erlbaum Associates.

Reys, E.R., (1971). Considerations for teachers using manipulative materials. *Arithmetic teacher*. *18*, 551-558

Ross, C. J. (2004). *The Effect Of Mathematıcal Manipulative Materials On Third Grade Students' Participation, Engagement, And Academic Performance.* Unpublished B.S. Thesis, University of Central Florida, Florida.

Rust, A. L. (1999). A Study of the Benefits of Math Manipulatives versus Standard Curriculum in the Comprehension of Mathematical Concepts, *Master's Program Action Research Project.* Johnson Bible College.

Salaam, L. (2006). Manipulatives and its effect on learning how to add positive and negative integers. Master Action Research Project, Marygrove College.

Schweinle, A., Meyer, D. K., & Turner, J. C. (2006). Striking the right balance: Students' motivation and affect in elementary mathematics. *Journal of Educational Research, 99*(5), 271-293.

Sowell, E. (1989). Effects of manipulative materials in mathematics instruction. *Journal for Research in Mathematics Education*, 20, 498-505.

Sprinthall, R. C., & Sprinthall, N. A. (1977). Educational Psychology: A Developmental Approach. Addison-Wesley Pub. Comp., USA.Strom, J. (2009). Manipulatives in Mathematics instruction. *Master's Program Action Research Project*. Bemidji State University. 1-45

Stigler, J. W., Lee S. Y & Stevenson, H.W. (1990). *Mathematical Knowledgeof Japanese, Chinese, and American elementary school children.* Reston, VA: National Council of Teaching of Mathematics.

Suydam, M. N., & Higgins, J. L. (1976). Review and Synthesis of Studies of Activity-Based Approaches to Mathematics Teaching. Final Report, NIE Contract No. 400-75-0063.

Szendrei, J. (1996). Concrete materials in the classroom. In A. J. Bishop (Ed.), *International handbook of mathematics education* (pp. 411-434). Netherlands: Kluwer Academic Publishers.

Tapan, M.S. & Arslan C. (2009). Preservice teachers' use of spatio-visual elements and their level of justification dealing with a geometrical construction problem. *US-China Education Review*, *6*(3), 54-60.

Thomas, G. P. (1975). Field Impact Evaluation. Monmouth, Oregon: Teaching Research, Oregon State System of Higher Education .

Thompson, P. (1994). Concrete materials and teaching for mathematical understanding. *The Arithmetic Teacher, 41* (9), 556-558.

Thompson, P. W. & A. G. Thompson (1994). Talking about rates conceptually, Part I: A teacher's struggle. *Journal for Research in Mathematics Education,* 25(3), 279-303.

Touger, H. (1986). Models : Help or hindrance? *Arithmetic teacher*, *33*(7), 36-37.

Toptaş, V. (2006). İlköğretim matematik dersi (1-5) öğretim programının uygulanmasında sınıf öğretmenlerinin karşılaştıkları sorunlarla ilgili görüşleri. Ulusal Sınıf Öğretmenliği Kongresi, Bildiri K.tabı, Cilt 1, 277-285. Ankara: Kok Yayıncılık.

Van Hiele, P. M., & van Hiele- Geldof, D. (1958). A method of initiation into geometry at secondary schools. In Fuys et al (1988). *The van Hiele model of thinking in geometry among adolescents. Journal for Research in Mathematics Education Monograph Series 3* .Reston, VA: National Council of Teachers of Mathematics.

Van Hiele, P.M. (1999). Developing geometric thinking through activities that begin with play. *Teaching children mathematics*, 6, 310-316.

Witzel, B. S. & Allsopp, D. (2007). Dynamic concrete instruction in an inclusive classroom. *Mathematics Teaching in the Middle School, 13*(4), 244-248.

Weiskirch, R. S. (2003). *Dealing with Piaget : Analyzing Card Games for Understanding Concepts.* Paper presented at the annual Conference of the American Psychological Association, p12.

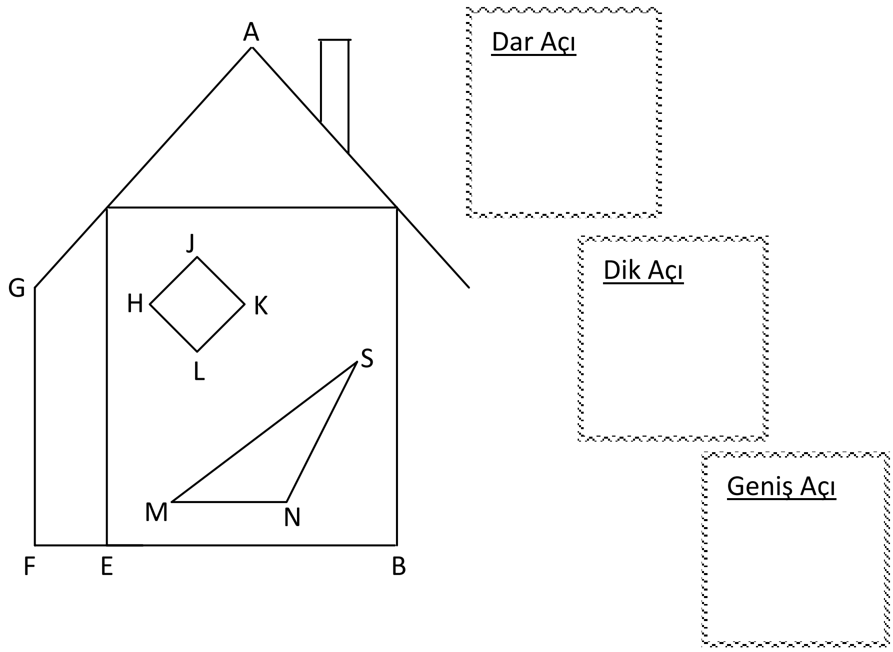
Yıldız, B. T. (2004). *Preservice teachers' attitudes toward the use of manipulatives: The influence of field experience and method course*. Unpublished master's thesis. Middle East Technical University, Ankara.

APPENDICES

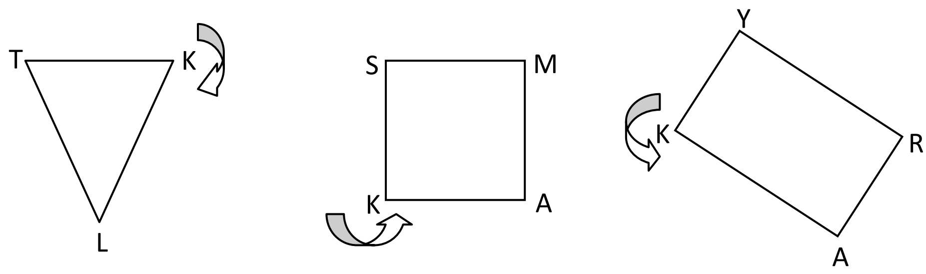
A. GEOMETRY ACHIEVEMENT TEST

Ad-Soyad:

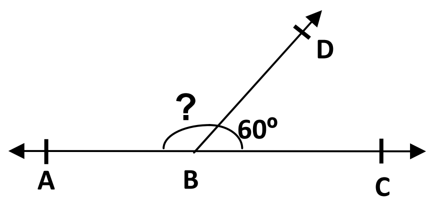
1. Aşağıdaki resimden birer tane **dar**, **dik** ve **geniş** açı bulunuz. Bulduğunuz açıları ölçünüz ve uygun boşluklara isimleri ile yazınız. Bulduğunuz açının çeşidini nasıl belirlediniz, nedenleri ile açıklayınız.



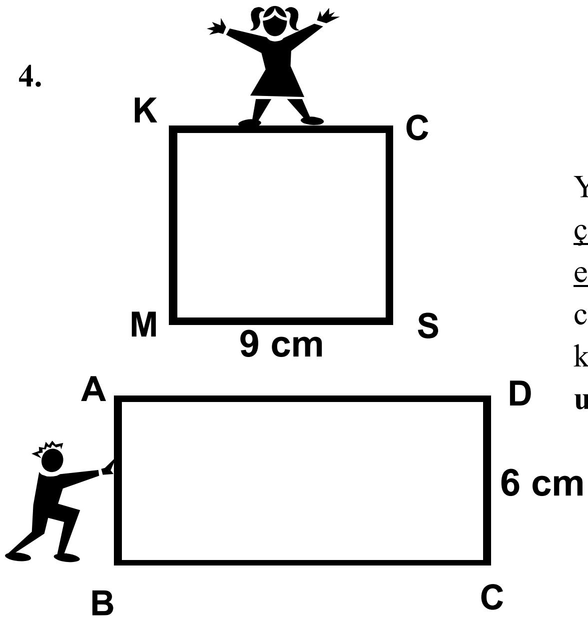
2. Ahmet, satın almak için aşağıdaki bahçelerin çevresini dolaşıyor. Her bahçenin **K** köşesinden yola çıkan Ahmet, okla gösterilen yönde ilerliyor ve başladığı köşede turunu tamamlıyor. Buna göre, Ahmet'in dolaştığı yönde üçgen, kare ve dikdörtgen biçimindeki bahçeleri köşelerindeki harflere göre <u>isimlendiriniz</u>.



....

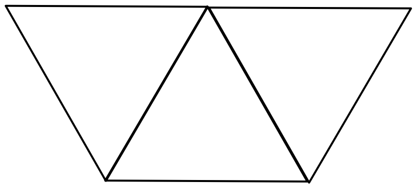
3. 

Yandaki şekilde "**?**" yerine gelmesi gereken açının ölçüsü kaç derecedir?

4. 

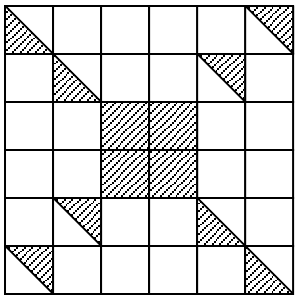
Yandaki kare ve dikdörtgenin <u>çevre uzunlukları birbirine eşittir</u>. Karenin bir kenarı 9 cm'dir. Dikdörtgenin kısa kenarı 6 cm olduğuna göre **uzun kenarı** kaç cm'dir?

5. Cem, birbirine eş 3 eşkenar üçgenden oluşan resim çerçevesini kırmızı ve mavi kurdeleler kullanarak süsleyecektir. Üçgenlerin herbirinin çevresi için 12 cm'lik kırmızı kurdele kullanmıştır. <u>Tüm</u> çerçevenin çevresini mavi kurdele ile süsleyen Cem, kaç cm **mavi** kurdele kullanmıştır?



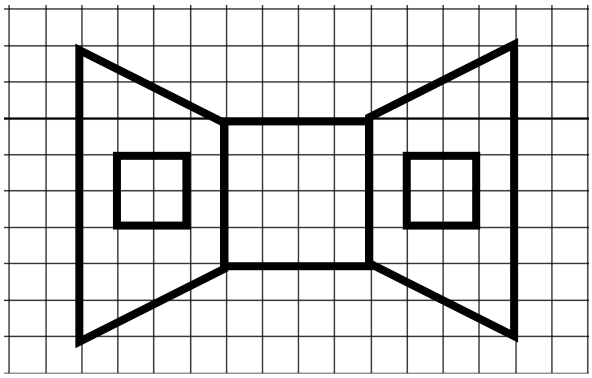
Ç = ...

6. Aşağıda verilen şekilde taralı olan parçaların toplam alanı kaç birim karedir, yazınız.

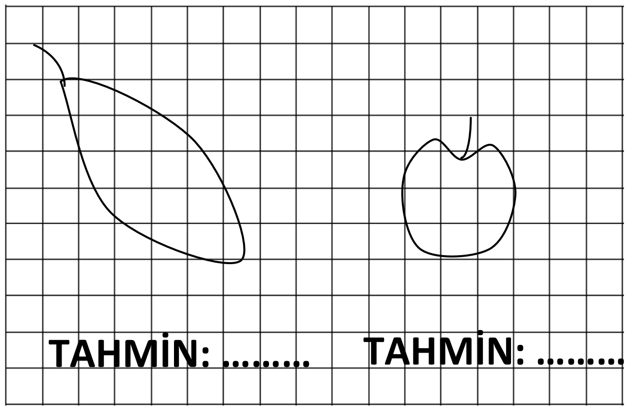


....

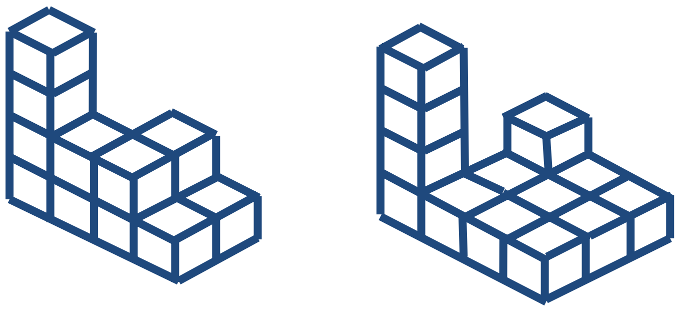
7. Aşağıda verilen şeklin simetri doğrusunu veya doğrularını simetri aynası yardımıyla çiziniz. Çizdiğiniz simetri doğrusu veya doğrularına nasıl karar verdiniz, açıklayınız.



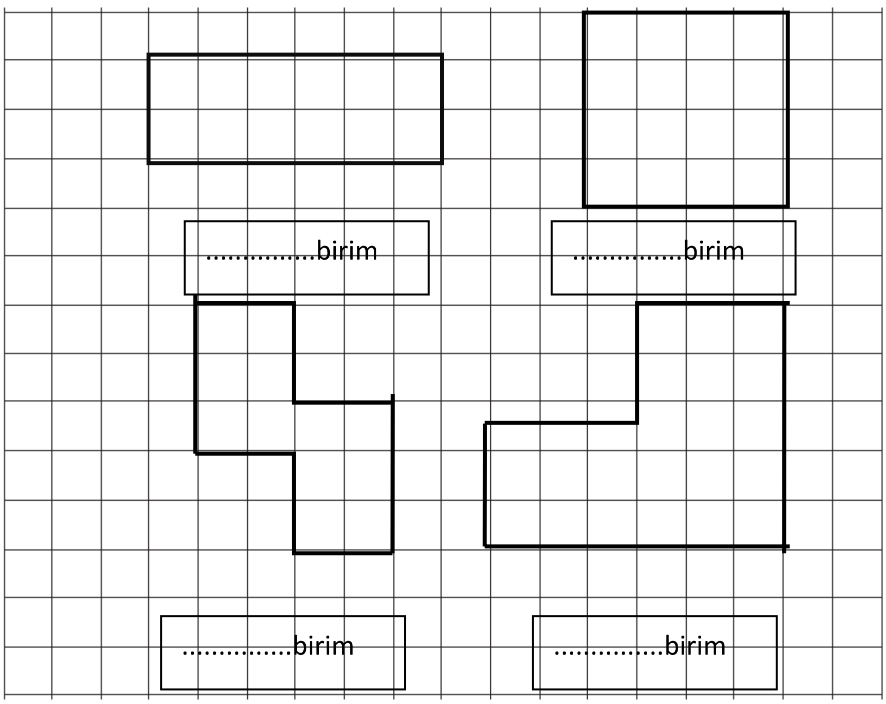
8. Aşağıda kareli kağıt üzerinde verilen şekillerin alanlarının kaç birim kare olduğunu tahmin ederek sonuçlarınızı şekillerin altına yazınız. Hangisinin alanı en küçüktür işaretleyiniz. Nasıl tahmin ettiğinizi açıklayınız.



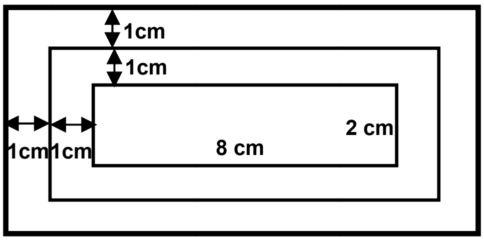
9. Aşağıdaki izometrik kâğıttaki çizimleri eş küplerle oluşturunuz. Şekilleri oluştururken kaç tane küp kullandığınızı şekillerin altına yazınız.



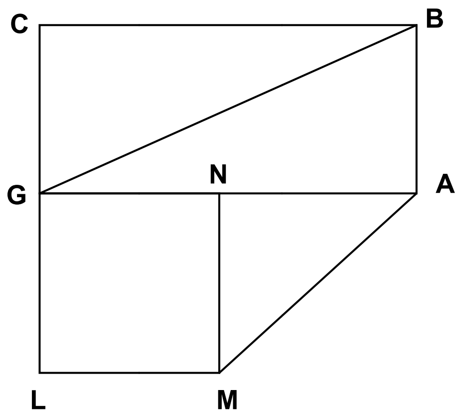
10. Aşağıda verilen her şeklin <u>çevresinin</u> kaç birim olduğunu şeklin altına yazınız.



11. Aşağıda, iç içe dikdörtgenlerden oluşan bir çerçeve bulunmaktadır. Dikdörtgenlerin kenarları arasındaki uzaklık 1 cm'dir. En içteki dikdörtgenin kısa kenarı 2 cm, uzun kenarı 8 cm olduğuna göre çerçevenin **çevresi** kaç cm'dir?

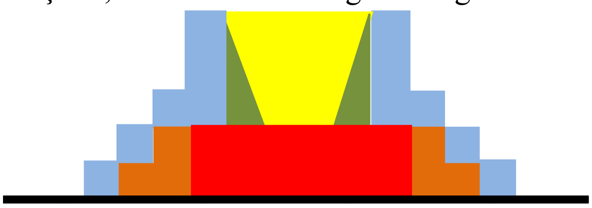


12.

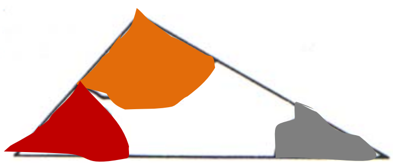


Yandaki şekilde bir köşegen var mıdır? Varsa belirtiniz.

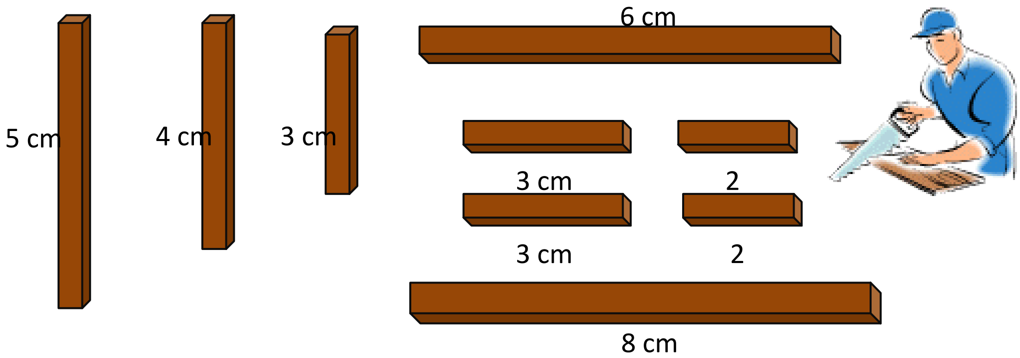
13. Aşağıdaki şekli, verilen simetri doğrusuna göre tamamlayınız.



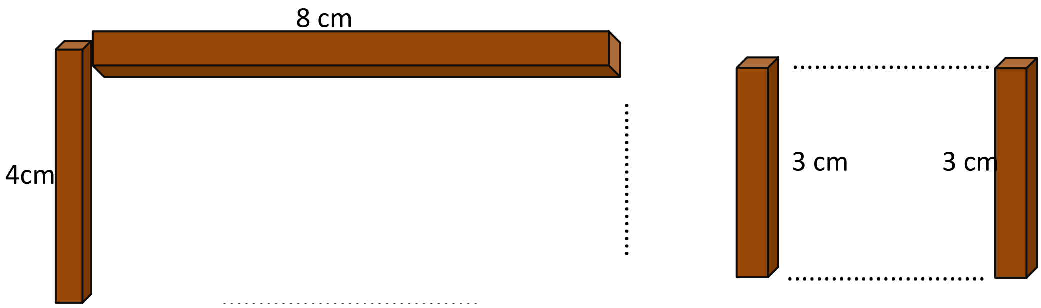
14. Üçgen şeklindeki bir kağıt katlanarak bir zarf yapılacaktır. Öncelikle, kağıdın aynı yüzündeki açıları farklı renge boyanır. Kağıt, boyanmış açıların köşeleri birbirine değecek şekilde dışa doğru katlanır. Katlama sonunda boyalı kısımların oluşturduğu açı ne tür bir açıdır? Açıklayınız.



15.

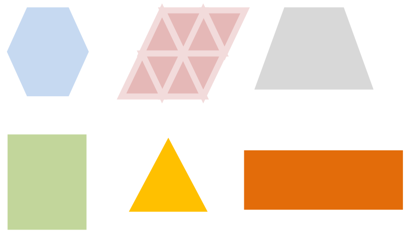


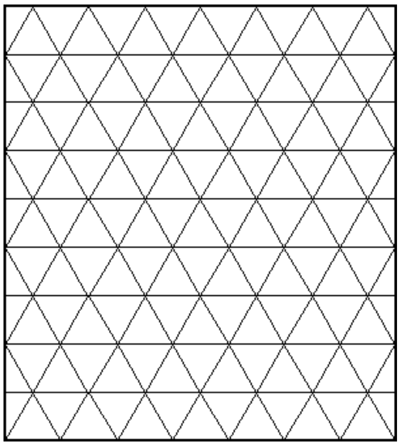
Bir marangoz yukarıdaki tahta parçalarını birleştirerek aşağıdaki gibi kare ve dikdörtgen şeklinde pencere çerçeveleri oluşturacaktır. Yukarıdaki parçalardan uygun olanları, uzunluklarını yanlarına yazarak aşağıda boş bırakılan yerlere çizer misiniz?

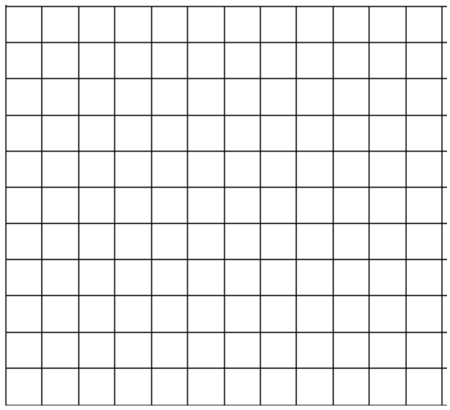


16.

Aşağıda verilen kağıtlardan birini seçiniz. Seçtiğiniz kağıdın üzerine, yandaki şekillerden uygun olanlarını kullanarak dilediğiniz süslemeyi yapınız.







B. TABLE OF SPECIFICATION

Objectives	Question Numbers
Name and show angles with symbols.	1
Measure the angles with standard units and determine acute, right and obtuse angles.	
Classify the triangle according to its angles.	
Name the triangle, square and rectangle.	**2**
Draw the acute, obtuse and right angled triangle by using protractor, miter joint and ruler.	**3**
Construct different geometric shapes having the same perimeter.	**4**
Determine the perimeter of planar shapes.	**4,5**
Determine the area of planar shapes as the number of unit squares that the given area includes.	**6**
Determine and draw the symmetry lines of planar shapes.	**7,13**
Make predictions about the area of the given shapes with non standard measurement tools and control the results by counting the units of the given area.	**8**
Construct the drawn shapes on isometric grid by using unit cubes.	**9**
Determine the relationship between the sides' length and perimeter of square and rectangle.	**10**
Solve and make problems about finding the perimeter of planar shapes.	**4,5,11**
Determine the diagonal.	**12**
Determine the sum of the interior angles of the triangle.	**14**
Determine the side and angle properties of square and rectangle.	**15**
Making tessellation by using appropriate shapes without leaving spaces.	**16**

C. SAMPLE LESSON PLANS

GEOMETRİK ŞEKİLLER

SINIF: 4 / A-B-C-D-E-F-G
Tarih: 13 Nisan-7 Mayıs

ÖĞRENME ALANI: GEOMETRİ

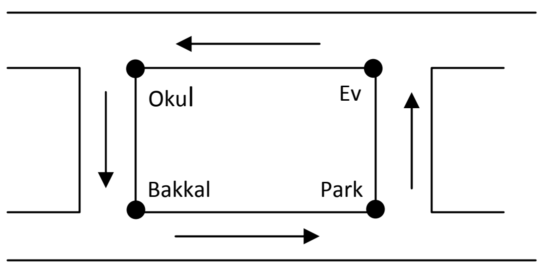
ALT ÖĞRENME ALANI: Üçgen, Kare ve Dikdörtgen

KAZANIMLAR

1. Üçgen, kare ve dikdörtgeni isimlendirir.
2. Üçgen, kare ve dikdörtgenin kenarlarını isimlendirir.
3. Kare ve dikdörtgenin, kenar ve açı özelliklerini belirler.
4. Köşegeni belirler.
5. Üçgenleri kenar uzunluklarına göre sınıflandırır.
6. Üçgenleri açı ölçülerine göre sınıflandırır.
7. Üçgenin iç açılarının ölçülerinin toplamını belirler.
8. Açıölçer, gönye veya cetvel kullanarak dik üçgen, kare ve dikdörtgeni çizer.

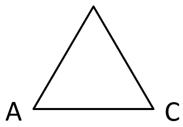
ÖLÇME VE DEĞERLENDİRME: Konu anlatımı, soru-cevap, keşfetme, boşluk doldurma, genel izlenim değerlendirme

Üçgen, kare ve dikdörtgenin herhangi bir köşesinden başlanarak saat yönünde veya tersi yönünde ilerlenir. Bunların her bir köşesindeki harfler sırayla yazılarak isimlendirilir.



Bora, bir pazar sabahı matematik kursu için evden okula gitti. Matematik kursundan sonra bakkala giderek bir şeker aldı ve şekerini yiyerek parka gitti. Parkta bir süre oynadıktan sonra eve döndü. Bora'nın pazar günü evden çıkarak izlemiş olduğu yol;

Okul → Bakkal → Park → Ev olarak ifade edilebileceği gibi kısa yolla OBPE şeklinde de ifade edilebilir. Bu senaryonun şematik gösterimi aşağıdaki gibidir:

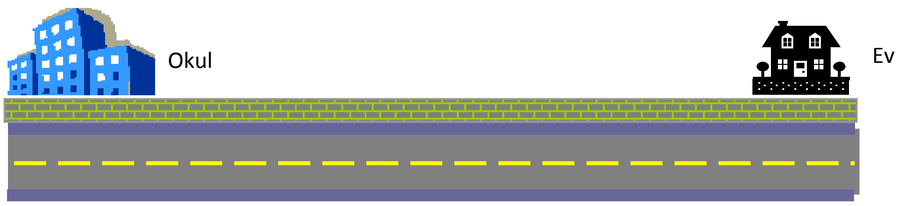


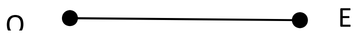
Yandaki üçgen, “ABC, ACB, BAC, BCA, CAB veya CBA üçgeni” olarak isimlendirilir ve sembolik olarak ∆ ABC veya $\overset{\Delta}{ABC}$ olarak gösterilir.

Doğru parçası

🏠 Öğrencilerin her bir kenarın, farklı iki köşeyi oluşturan iki uç noktası olduğunu gözlemlemeleri sağlanır. Bu uç noktalar belli olunca kenarın yani doğru parçasının belirlendiği ve bu doğru parçasının iki köşeyi birleştiren en kısa yol olduğu fark ettirilir.

Doğru parçası modeli olarak okul ile ev veya ev ile okul arasındaki düz yol aldırılır. Bu yolun “okul-ev arası veya yolu” ya da “ev-okul arası yolu” biçiminde adlandırıldığı gibi bir doğru parçasının uçlarının adını vererek isimlendirildiği fark ettirilir.





“OE doğru parçası” veya “EO doğru parçası”

Bu doğru parçası $\overline{OE}$ veya $[OE]$ ile gösterildiği gibi $\overline{EO}$ veya $[EO]$ ile gösterilir.

$\overline{OE}$ ’nin uzunluğu OE veya |OE| ile de gösterilir.

Örneğin; OE doğru parçasının uzunluğu 4 cm’dir |OE| = 4 cm şeklinde ifade edilir.

🏠 $\overset{\Delta}{ABC}$ üçgenindeki AB kenarı [AB], [BA] ya da $\overline{AB}$, $\overline{BA}$; PTRS karesindeki TR kenarı da [TR], $\overline{TR}$, [RT] veya $\overline{RT}$ biçiminde gösterilir.

Ödev: Çalışma kitabı sayfa 46, 47

Köşegen

[!] Kenar ile köşegen arasındaki fark vurgulanır.

Kare ve dikdörtgenin komşu olmayan iki köşesini uç kabul eden doğru parçasına köşegen denir.

🖮 Kare ve dikdörtgenin kâğıt modelleri, çapraz köşelerini birleştiren doğru parçası boyunca katlattırılarak bunların köşegenleri buldurulur. Oluşan izler boyunca köşegenler çizdirilir ve adlandırılır. Bu köşegenlerin her birinin doğru parçası olduğu ve birbirlerine eş uzunlukta oldukları belirtilir.

🖮 Geometri tahtası veya noktalı kâğıt kullanılarak çeşitli büyüklükte kare ve dikdörtgenler oluşturulur. Oluşturulan kare ve dikdörtgen inceletilerek bunların kenar ve açılarının özellikleri belirtilir. Bu özellikler karşılaştırılarak kare ve dikdörtgenin benzerlik ve farklılıkları buldurulur.

[!] Üçgen, kare ve dikdörtgenin kenarlarının aynı zamanda bir doğru parçası olduğu vurgulanır.

KARE

- ❖ Kenar uzunlukları birbirine eşit ve karşılıklı kenarları birbirine paralleldir.
- ❖ Kenarları: AB , BC, CD ve DA doğru parçalarıdır.
- ❖ İç açıları 90º ’ dir.
- ❖ 2 tane köşegeni vardır.

Ödev: Matematik Gezegeni 5 sayfa 19

DİKDÖRTGEN

- ❖ Dikdörtgenin karşılıklı kenarlarının uzunluğu birbirine eşit ve birbirine paraleldir.
- ❖ Kenarları: KL, LM, MN ve NK doğru parçalarıdır.
- ❖ İç açıları 90º ’dir.
- ❖ 2 tane köşegeni vardır.

Ödev: Matematik Gezegeni 5 sayfa 22

ÜÇGEN

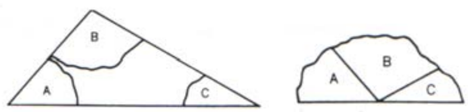
Giriş: Ders kitabı sayfa 82, 83, 84, Öğretmen kılavuz kitabı sayfa 84, 85, 86

Üçgenlerin kenar uzunluklarına göre sınıflandırılması yapılırken önce sezgiye dayalı olarak ikizkenar, eşkenar ve çeşitkenar üçgeni birbirinden ayıran özelliklerin ne olduğu tartıştırılır.

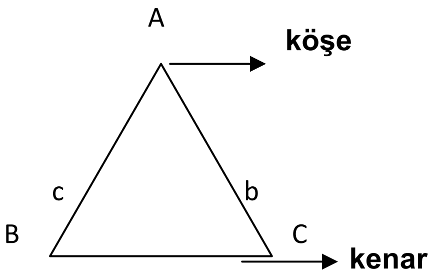
Ölçme yaptırılarak farklılıklar ortaya çıkartılır.

Kâğıttan bir üçgen modeli üç köşesinden koparttırılıp elde edilen parçaların köşeleri bir noktada yan yana getirtilerek bir doğru açı oluştuğu buldurulur.

Kâğıttan bir üçgen modelinin açıları ölçtürülüp bir noktadan itibaren bitişik olarak çizdirilerek doğru açı oluşturdukları buldurulur.



Üçgenin iki iç açısının ölçüsü verildiğinde üçüncü açısının ölçüsünün nasıl bulunacağı sorgulatılır.



[!]Üçgenin köşegeni olmadığı belirtilir.

- A,B,C üçgenin köşeleridir. Bu köşeler aynı zamanda üçgenin açılarıdır. $\hat{A}, \hat{B}, \hat{C}$
- AB (b), BC (a), CA (c) doğru parçaları üçgenin kenarlarıdır.
- Kenarlar karşılarındaki açıların adları ile küçük harfle isimlendirilirler. a, b, c
- Üçgenin iç açılarının toplamı 180^0 dir.

Ödev: Matematik Gezegeni 5 sayfa 27

Çalışma kitabı sayfa 48, 49

ÜÇGEN ÇEŞİTLERİ

Çizilmiş olarak verilen üçgenlerin kenar uzunlukları ölçtürülür. Ölçme sonuçlarına göre üçgenler ikizkenar, eşkenar ve çeşitkenar üçgen olarak isimlendirilir.

Üçgenler açı ölçülerine göre sınıflatılırken önce sezgisel olarak dik, geniş ve dar açılı üçgeni birbirinden ayıran özelliklerin ne olduğu tartıştırılır. Ölçme yaptırılarak farklılıklar ortaya çıkartılır.

ÜÇGEN ÇEŞİTLERİ

Açılarına göre

1. Dar açılı üçgen ; Tüm iç açılarının ölçüsü 90º'den küçük olan üçgenlerdir.

2. Dik açılı üçgen (Dik üçgen) ; Bir iç açısının ölçüsü 90º olan üçgenlerdir.

Kenarlarına göre

1. Eşkenar üçgen ;Tüm kenar uzunlukları birbirine eşit olan üçgenlerdir.

2. İkizkenar üçgen ; İki kenar uzunluğu birbirine eşit olan üçgenlerdir.

Geometri tahtası veya noktalı kağıt kullandırılarak farklı duruşlardaki üçgen çeşitleri oluşturulur.

Geometri tahtası veya noktalı kağıt kullandırılarak farklı duruşlardaki üçgen çeşitleri oluşturulur.

Çizilmiş olarak verilen üçgenlerin açıları ölçtürülür. Ölçme sonuçlarına göre üçgenler dik, dar ve geniş açılı üçgen olarak adlandırılır.

🖎 Farklı büyüklükte üçgenler çizdirilerek iç açıları ölçtürülür. Bu açıların ölçüleri toplamı buldurulur.

Ödev: Matematik Gezegeni 5 sayfa 25, 26

Çalışma kitabı sayfa 50, 51, 52

Ünite sonu alıştırmaları

Ders Kitabı sayfa 87, 88 (2. ünite sonu değerlendirmesi)

Çalışma kitabı sayfa 53, 54, 55, 56 (2. ünite sonu testi)

Çalışma kitabı sayfa 46, 47, 48, 49, 50

AÇILAR

DERS: Matematik **TARİH:** 30 Mart - 03 Nisan 2009

SINIF: 4 / A-B-C-D-E-F-G

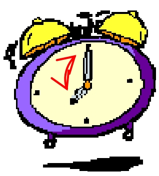
ÖĞRENME ALANI: GEOMETRİ

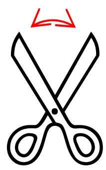
ALT ÖĞRENME ALANI: Açı ve Açı Ölçüsü

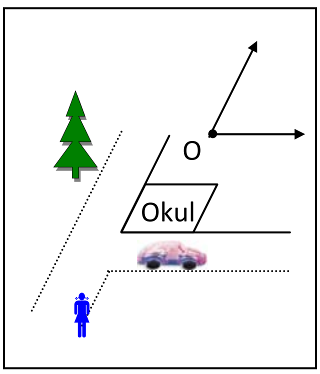
KAZANIMLAR
Açının kenarlarını ve köşesini belirtir.
Açıyı isimlendirir ve sembolle gösterir.
Açıları, standart olmayan birimlerle ölçerek standart açı ölçme biriminin gerekliliğini açıklar.
Açıları standart açı ölçme araçlarıyla ölçerek açıları; dar, dik, geniş ve doğru açı olarak belirler.
Ölçüsü verilen bir açıyı çizer.
Açıların ölçülerini tahmin eder ve tahminini açıyı ölçerek kontrol eder.

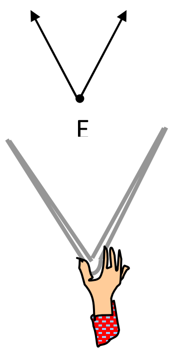
ÖLÇME VE DEĞERLENDİRME: Konu anlatımı, soru-cevap, keşfetme, boşluk doldurma, genel izlenim değerlendirme

Saat modeli üzerinde akrep ve yelkovanın açının kenarları, bunları tutan pimin de açının köşesi; vücut modelinde kol ve bedenin açının kenarları, omuzun da açının köşesi; makas modelinde bıçakların açının kenarları, pimin de açının köşesi olduğu fark ettirilir.





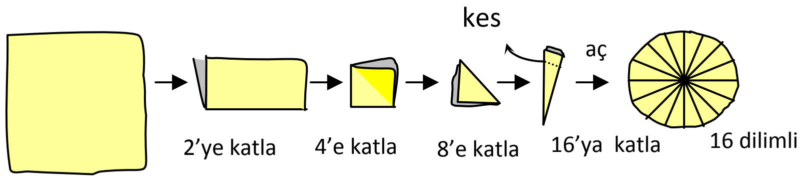


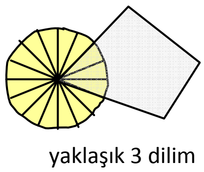


Açının kenarlarının birer ışın olduğu uygun modeller yardımıyla vurgulanır.

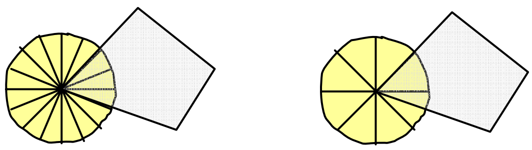
[!]Yuvarlak pastada merkezden kenara doğru kestiğimiz dilimlerin “büyük” veya “küçük” genişlikte olma durumları; kapının yarı açık, tam açık, kapalı durumları vb. model alınarak her açının bir büyüklüğü olduğu ve bu büyüklüğün, uzunluk veya sıvılar gibi ölçülebileceği vurgulanır.

Kâğıttan standart olmayan açı ölçer modelleri yaptırılır. Şekilde gösterildiği gibi yapılan katlamaların sayısı arttıkça elde edilen dilimlerin sayısının arttığı ve dilimlerin küçüldüğü fark ettirilir. Farklı dilimlere sahip açıölçer modelleri ile yaptırılan ölçüm sonuçları karşılaştırılır.



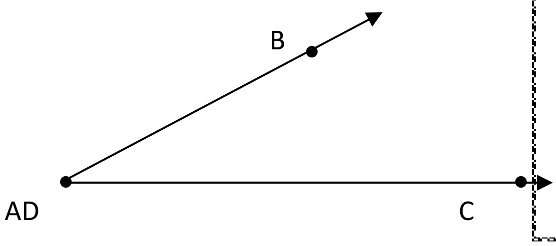


Kâğıttan yapılan açıölçer modelleri kullandırılarak düzlemdeki bir çokgenin açıları ölçtürülür.



AÇI

Defterinize bir A noktası alınız. Bu noktadan çıkan AB ve AC ışınlarını çiziniz. Başlangıç noktaları aynı olan bu iki ışının oluşturduğu noktalar kümesine “açı” denir.



- A noktası açının köşesidir.
- AB ve AC ışınları açının kenarlarıdır.
- Açı, köşesindeki harfle isimlendirilir.

Açı ölçüsü birimi derecedir. Sayının sağ üst köşesine koyulan “°” sembolü ile gösterilir. Açı iletki ile ölçülür.

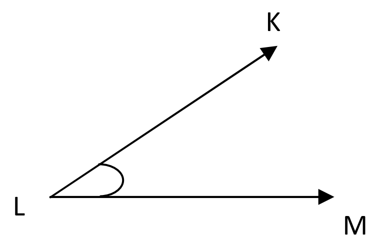
[!]Açı ölçüsünün en az 0° ve en fazla 180° olduğu vurgulanır.

[!]Açıyı, köşesine yazılacak olan büyük harfle isimlendirmeleri sağlanır.

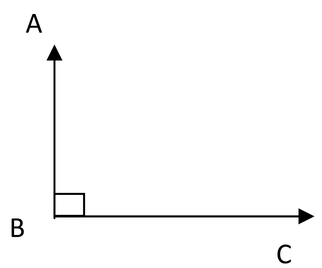
[!] Açı formal olarak tanımlanmaz.

AÇI ÇEŞİTLERİ

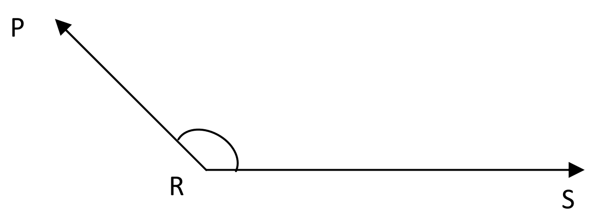
1. Ölçüsü 90^0 den küçük olan açılara **dar açı** denir.



2. Ölçüsü 90^0 olan açılara **dik açı** denir.



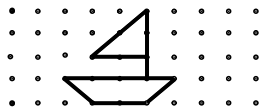
3. Ölçüsü 90^0 den büyük olan açılara **geniş açı** denir.



Sınıf çalışması: Ders kitabı syf 48

Ödev: Matematik Gezegeni syf 13, 14

Noktalı kâğıtta verilen bir şeklin içindeki açılar ölçtürülerek dar, dik ve geniş açıların sayıları buldurulur. Akrep ve yelkovanın saat başlarındaki durumları model alınarak hangi saatlerde hangi açıların oluştuğu yazdırılır.



Geometri tahtası üzerinde sadece bir dik açısı olan, en az bir dik açısı olan, altı dik açısı ve yedi kenarı olan vb. düzlemsel şekiller oluşturtulur.

Ödev: Çalışma kitabı syf 27, 28, 29, 30

Ölçüsü Verilen Açıyı Çizme

[!]Aynı ölçüye sahip açıların duruşlarındaki farklılığın, açının ölçüsünde etkili olmadığı vurgulanır.

Örnek: Aşağıda ölçüsü verilen açıları çiziniz. Çeşidini yazınız.

1. 45^{o}
2. 15^{o}
3. 90^{o}

1) Bir dik açı ile bir dar açının ölçüleri toplamı 135^{o}'dir. Dar açının ölçüsü kaç derecedir? Cevap: 45^{o}

2) İki dar açının toplamı en fazla kaç olabilir? Cevap: 178^{o}

3) İki geniş açının toplamı en az kaç olabilir? Cevap: 182^{o}

4) En büyük dar açı ile en küçük geniş açının toplamı kaç derecedir? Cevap: 180^{o}

5) 45 derecelik bir dar açı ile bir geniş açının toplamı en az kaç derece olabilir? Cevap: 136^o

6) Bir geniş açı ile bir dar açının toplamı 120^o dir. Bu açılardan dar olanı en fazla kaç derece olur? Cevap: 29^o

7) Aralarında 10^o fark olan iki açının toplamı bir dik açı oluşturmaktadır. Büyük açı kaç derecedir? Cevap: 50^o

8) Biri diğerinin iki katı olan iki açının toplamı bir dik açı olduğuna göre

a) Bu açıları bulunuz. Cevap: 30^o ve 60^o

b) Açıların farkını bulunuz. Cevap: 30^o

9) Biri diğerinin 5 katı olan iki açının toplamı bir doğru açıdır. Büyük açı kaç derecedir? Cevap: 150^o

10) İki açının toplamı bir doğru açı oluşturmaktadır. Açılardan biri dik açıdan 15^o fazla olduğuna göre diğer açının ölçüsü kaç derecedir? Cevap: 75^o

D. SAMPLE ACTIVITIES

Konu: Üçgen, Kare ve Dikdörtgen

Sınıf: 4

Süre:40 dakika

Ön Koşul Bilgiler: iletki kullanabilme

Ön Koşul Beceriler: Akıl yürütme ve psikomotor beceriler

Kazanımlar:

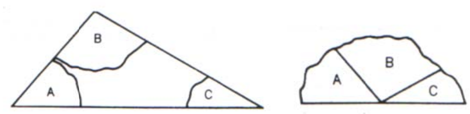
1. Üçgenin iç açılarının ölçülerinin toplamını belirler.

Materyaller: renkli kalem, kağıt, makas

İşleniş:

Etkinlik 1:

- Kâğıttan bir üçgen modeli üç köşesinden koparttırılıp elde edilen parçaların köşeleri bir noktada yan yana getirtilerek bir doğru açı oluştuğu buldurulur.



- Doğru açının kaç derece olduğu sorulur. Buradan üçgenin iç açıları toplamının kaç derece olduğu bulunur.
- Verilen üçgenlerin iç açıları ölçtülerek iç açıları ölçüsünün toplamları buldurulur.
- İki iç açısı verilen üçgenin diğer açısının nasıl bulunacağı sorgulatılır.

Etkinlik 2:

Öğrenciler bir kağıda üçgen çizip şekli keser. Daha sonra, üçgenin üç açısını da farklı renkte boyar ve boyadıkları köşeleri aynı yönde katlar. Katladıkları üç farklı renkteki açının nasıl bir açı olduğu sorgulatılır.

Konu: Alan

Sınıf: 4

Süre: 40 dakika

Ön Koşul Bilgiler: Doğal sayılarda toplama işlemi

Ön Koşul Beceriler: Akıl yürütme, ilişkilendirme, duyuşsal beceriler, psikomotor beceriler

Kazanımlar:

1. Bir alanı, standart olmayan alan ölçme birimleriyle tahmin eder ve birimleri sayarak tahminini kontrol eder.
2. Düzlemsel bölgelerin alanlarının, bu alanı kaplayan birim karelerin sayısı olduğunu belirler.
3. Karesel ve dikdörtgensel bölgelerin alanlarını birim kareleri kullanarak hesaplar.

Materyaller : Geometri tahtası, lastik, renkli kartonlar, renkli kalemler, silgi, makas, CD kapağı, CD

İşleniş

Etkinlik :

- Öğrencilere ilk olarak kaç tane CD kapağı ile öğretmen masasını kaplayabilecekleri sorulur. Öğrencilerin tahminleri alınır ve tahtaya yazılır. Daha sonra, gönüllü bir öğrenciye CD kapakları ile öğretmen masası kaplatılarak alan yaklaşık olarak buldurulur.

  Öğretmen masasının bu kez de daire şeklindeki CD'ler ile kaplanırsa, ne kadar CD gerekeceği sorulur. Öğretmen masası daire şeklindeki CD'ler ile kaplatılarak alanı yaklaşık olarak ifade ettirilir.

  Öğrencilere, alanı ölçmek için kare şeklindeki CD kapağının mı, daire şeklindeki CD'lerin mi daha uygun olduğu sorulur. Öğrencilerin düşünceleri alınır ve tartışılır. Eğer öğrenciler ortak bir karara varamazsa "Hangisi ile kaplandığında kalan boşluk daha azdır?" sorusu sorulur.

Öğrencilerin cevabı alındıktan sonra alan hesaplamak için birim olarak karelerin kullanıldığı vurgulanır.

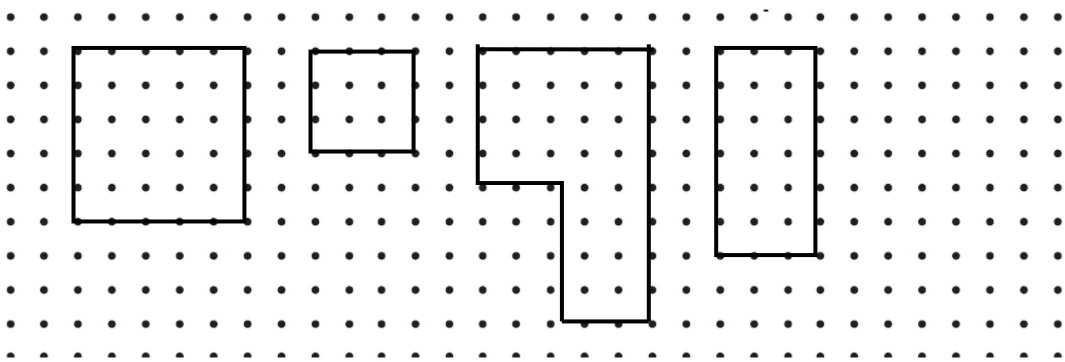
- Düzgün veya düzgün olmayan düzlemsel şekiller geometri tahtası üzerine yapıştırılır ve öğrencilerden şekillerin alanlarını tahmin etmeleri istenir.

Her öğrenciden veya grup elemanından elinin şeklini kareli defter kağıdına çizmeleri istenir ve ellerinin kapladığı alanı nasıl bulacakları sorulur. Elinin kapladığı alanda tam kareleri maviye, yarım kareleri sarıya boyar ve bu karelarin sayısını bulur. Maviye boyadığı karelerin sayısı ile sarıya boyadığı karelerin sayısını toplar. Elinin yaklaşık olarak alanının ne olduğu sorulur ve elinin alanının mavi karelerin sayısı ile mavi karelerin sayısı+sarı karelerin sayı arasında olduğunun sonucuna varılır.

- Geometri tahtası üzerinde karesel bölgenin alanının, bu alanı kaplayan birim karelerin sayısı olduğu önce birim kareler saydırılarak buldurulur. Çizdirilen bu karesel bölgenin alanının; farklı iki kenarı kaplayan birim karelerin sayısının çarpımı olduğu, çizim üzerinde buldurulur. Benzer etkinlikler dikdörtgen için de yaptırılır.

Alıştırmalar:

1. Aşağıdaki düzlemsel şekillerin alanlarının kaç birim kare olduğunu sayarak bulup içlerine yazınız.



E. SAMPLE POP QUIZZES

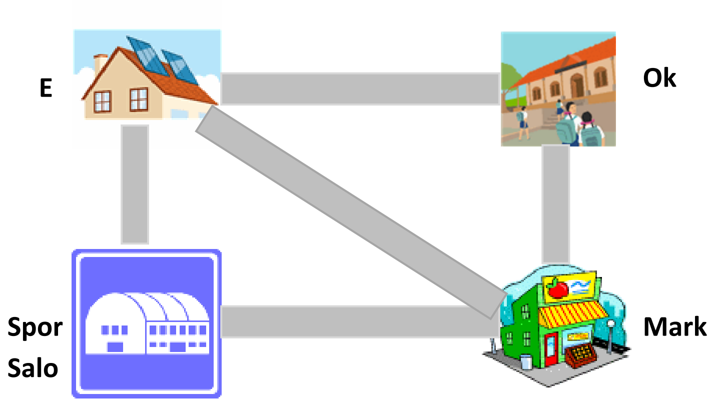
Pop Quiz 1

1) Aşağıda verilen kağıdın üzerine, yandaki şekillerden uygun olanlarını kullanarak dilediğiniz süslemeyi yapınız.

Pop Quiz 2

Arzu, her sabah evinden çıkıp spor salonuna gittikten sonra markete uğruyor ve daha sonra yeniden eve dönüyor. Arzu'nun izlediği yolu aşapıdaki boşluğa çiziniz.

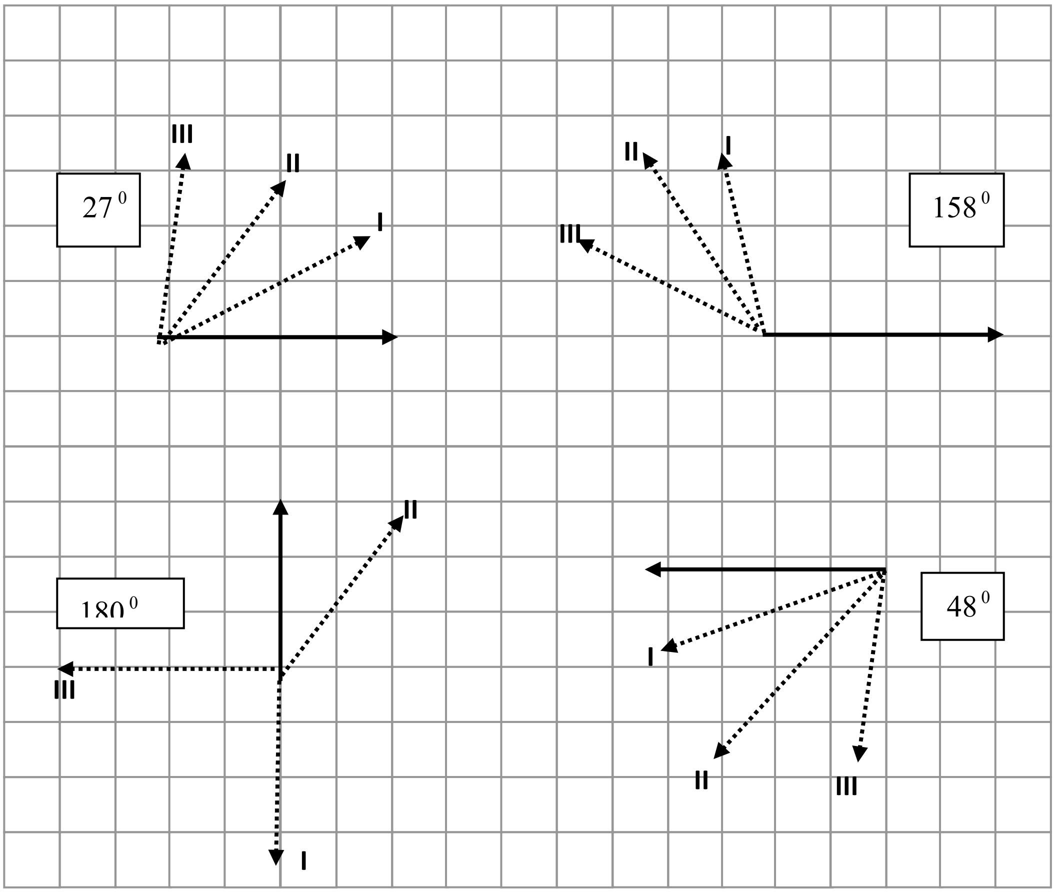
- **a)** Oluşan şekli köşelerindeki binaların baş harflerini kullanarak yanındaki boşluğa sembol kullanarak yazınız.
- **b)** Şekildeki üçgenlerin kenarlarının sembol kullanarak yazınız.



....

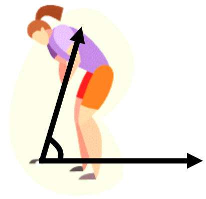
Pop Quiz 3

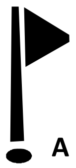
Aşağıdaki kareli kağıdın üzerinde, bir kenarları belirgin olarak çizilmiş açılar verilmiştir. Şekillerdeki numaralandırılmış kenarlardan hangisi seçildiğinde o şeklin yanında yazan ölçüde açı elde edilir?



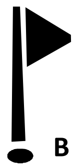
Pop Quiz 4

Cansu, bir golf antrenmanında golf topunu sırasıyla A, B ve C deliklerine sokmak istemektedir. Aşağıda verilen ipuçlarını kullanarak Cansu’nun ilgili deliklere kaç derecelik açı kullanarak isabetli atış yapacağını bulunuz. **(İşlemlerinizi gösteriniz.)**

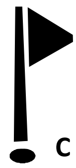




Cansu, sopasıyla yer arasında bir dik açıdan **40º eksik** açı oluşturmalıdır.



Cansu, sopasıyla yer arasında bir doğru açıdan **100º eksik** açı olusturmalıdır.



Cansu’nun sopasıyla yer arasında oluşturduğu açı bir doğal sayı olup, <u>en küçük geniş açıdan</u> **10º eksik** olmalıdır.

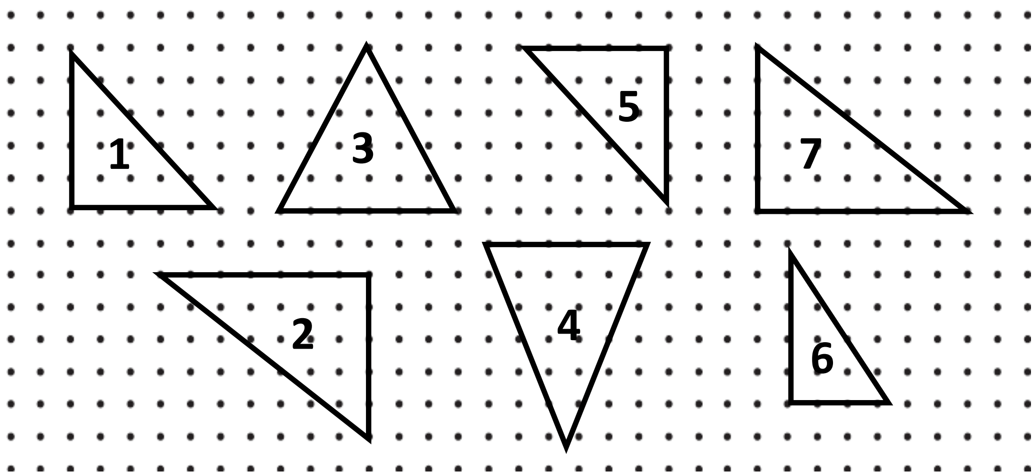
Pop Quiz 5

Aşağıdaki noktalı kağıt üzerinde değişik büyüklüklerde üçgenler numaralandırılarak verilmiştir.

Bu üçgenlerden kare veya dikdörtgen oluşturabilmek için hangileri birleştirilmelidir? Boşluklara

bu üçgenlerin numaralarını yazınız.

a) <u>Kare</u> ……………….. **b) <u>Dikdörtgen</u>** ………..



F. RUBRIC FOR GEOMETRY ACHIEVEMENT TEST

Question Number	At Level 1 Student	At Level 2 Student	At Level 3 Student	At Level 4 Student	At Level 5 Student
1	Students determine only one of the **acute, right and obtuse angles** and even if he/she writes the reasons while determining the angles.	Students determine two of the **acute, right and obtuse angles.** He/she does not write the reasons while determining the angles.	Students determine two of the **acute, right and obtuse angles.** He/she also writes the reasons while determining the angles.	Students accuretly and efficiently determine **acute, right and obtuse angles**. He/she does not write the reasons while determining the angles.	Students accuretly and efficiently determine **acute, right and obtuse angles**. He/she also writes the reasons while determining the angles.
2	Students write the names each one of the triangle, the square and the rectangle (like KARY,ABC…)correctly by starting to write from **stated or not stated corner** of the shapes even if he/she uses appropriate symbols or terms.	Students write the names each one of the triangle, the square and the rectangle (like KARY,ABC…)correctly by starting to write from **stated or not stated corner** of the shapes. He/she also uses appropriate symbols or terms.	Students write the names each two of the triangle, the square and the rectangle (like KARY,ABC…)correctly by starting to write from **stated or not stated corner** of the shapes. He/she also uses appropriate symbols or terms.	Students write the names all of the triangle, the square and the rectangle (like KARY,ABC…)correctly by starting to write from **not stated corner** of the shapes. He/she also uses appropriate symbols or terms.	Students write the names all of the triangle, the square and the rectangle (like KARY,ABC…)correctly by starting to write from **stated corner** of the shapes. He/she also uses appropriate symbols or terms.
3	Students thinks substraction but he/she does not mention the straight angle.	Students thinks straight angle correctly but he/she does not make any operation.	Students find the correct angle but he/she does not show the operation.	Students can not find the correct angle but the way he/she thinks is logically true.	Students find the correct angle and do not have arithmatical mistakes.
4	Students have limited understanding of finding the perimeter of square or rectangle to make a reasonable attempt.	Student applies the correct order of operations to find the perimeter of square or rectangle but he/she does not carry out the reverse operation.	Student applies the correct order of operations to find the perimeter of square but he/she makes operational mistakes. Then he/she continues with the reverse operation to find the side of the rectangle.	Student applies the correct order of operations to find the perimeter of square but while doing the reverse operation to find the side of the rectangle, he/she makes mistakes.	Student applies the correct order of operations to find the perimeter of square and then reverse the operation to find the side of the rectangle.
5	Students do not identify the properties of the equilateral triangle and they have limited understanding of finding the perimeter of square or rectangle to make a reasonable attempt.	Students do not identify the properties of the equilateral triangle but he/she also applies the correct strategy to find out the perimeter of the given shape but he/she makes operational mistakes.	Students do not identify the properties of the equilateral triangle but he/she also applies the correct strategy to find out the perimeter of the given shape. Or Students identify the properties of the equilateral triangle but he/she does not apply the correct strategy to find out the perimeter of the given shape.	Students identifies the properties of the equilateral triangle. He/she also applies the correct strategy to find out the perimeter of the given shape but he/she makes operational mistakes.	Students identifies the properties of the equilateral triangle. He/she also applies the correct strategy to find out the perimeter of the given shape.
6	Students have limited understanding of finding the area of shaded part of the given shapes.	Students count the semi-shaded squares as 1, and make mistakes while finding the total shaded area.	Students count the semi-shaded squares as 1, and do not make mistakes while finding the total shaded area.	Students count the semi-shaded squares as 0,5 and shaded squares as 1 but they make mistakes while finding the total shaded area.	Students accuretly and efficiently counts the shaded area of shapes.

Question Number	At Level 1 Student	At Level 2 Student	At Level 3 Student	At Level 4 Student	At Level 5 Student
7	Students do not draw each of the symmetry lines but he/she gives explanation.	Students draw only one of the symmetry lines and do not give explanation.	Students draw only one of the symmetry lines and give explanation.	Students draw all of the symmetry lines and do not give explanation.	Students draw all of the symmetry lines and give explanation.
8	Students estimate the area of one of the non-planar shape (small apple and big pear) approximately (more or less two) and do not write the explanation.	Students estimate the area of one of the non-planar shape (small apple and big pear) approximately (more or less one) and do not write the explanation.	Students estimate the area of one of the non-planar shape (small apple and big pear) approximately (more or less one) and write the explanation. Or Students estimate the area of one of non-planar shape (small apple and big pear) correctly and do not write the explanation.	Students estimate the area of all non-planar shape (small apple and big pear) correctly and do not write the explanation.	Students estimate the area of all non-planar shape (small apple and big pear) correctly and write the explanation.
9	Students incorrectly count the number of cubes used to construct any of the given three dimensional geometric shapes but he/she shows effort.			Students correctly count the number of cubes used to construct one of the given three dimensional geometric shapes.	Students correctly count the number of cubes used to construct both of the given three dimensional geometric shapes.
10	Students can not find the perimeter of any of given planar shapes on the dotted paper in terms of units but he/she basically understand the concept of finding the perimeter.	Students find the perimeter of one of given planar shapes on the dotted paper in terms of units.	Students find the perimeter of two of given planar shapes on the dotted paper in terms of units.	Students find the perimeter of three of given planar shapes on the dotted paper in terms of units.	Students find the perimeter of all given planar shapes on the dotted paper in terms of units.
11	Students show little progress of finding external rectangle's side values.		Students make and carry out a plan to find the perimeter of exterior rectangle (whose lengths are given) but he/she makes operational mistakes on writing the lengths of exterior rectangle. The plan only involves one side.	Students make and carry out a plan to find the perimeter of the exterior rectangle (whose lengths are not given but clues about the lengths are mentioned) correctly but he/she makes operational mistakes.	Students find the perimeter of interior rectangle (whose lengths are given) and the exterior rectangle (whose lengths are not given but clues about the lengths are mentioned) correctly.
12	Students have enough understanding of indicating diagonals, shown by their drawing on the diagram one or more diagonals without writing the correct answer.		Students draw other diagonals on the given shape or indicate the correct diagonal but do not use appropriate symbols or terms to represent it.	Students show the correct diagonal on the given shape but do not use appropriate symbols or terms to represent it. Or Students draw other diagonals on the given shape and use appropriate symbols or terms to represent it.	Students show the correct diagonal on the given shape and also use appropriate symbols or terms to represent it.
13	Students complete 25% of the symmetry or less of given planar shapes according to the given symmetry line.		Students complete about 50% of the symmetry of given planar shapes according to the given symmetry line.	Students do not complete the symmetry of given planar shapes according to the given symmetry line entirely.	Students complete the symmetry of given planar shapes according to the given symmetry line.
14	Students have some understanding of the sum of the angles of triangle but he/she does not write it correctly.		Students does not determine the type of angle but he/she write the explanation correctly.	Students determine the type of angle but he/she does not write the explanation correctly.	Students determine the type of angle and the explanation correctly.
15	Students draw one or both of the shapes but have not shown any other understanding of determining properties of rectangle and square.		Student writes only one of the shapes' (rectangle **or square**) length of the sides but he/she did not draw them.	Students write the length of the sides of either the square or the rectangle correctly and they also draw it.	Students write the length of the sides of the square and rectangle correctly. They also draw them.

F. INTERVIEW QUESTIONS WITH PURPOSES

Table 3.4.2 Interview Questions and Their Purposes

Questions	Purpose(s) of the Questions
What do you think about Math class?Why?	To examine the students' feelings about Mathematics.
What comes to your mind when you think about Math?	To get their first opinion about Mathematics.
How do concrete materials effect your geometry problem solving?Explain.	To investigate whether or not students' Geometry problem solving method show changes with concrete materials.
How do you feel when you first see the questions (pre-intervention) before using the concrete materials?	To examine the students' feelings **before** using concrete materials.
How do you feel when you second time see the questions (post-intervention) after using the concrete materials?	To examine the students' feelings **after** using concrete materials.
How do concrete materials effect your understanding of geometry? Explain.	To investigate the cognitive effects of concrete materials.
Do the activities effect your understanding of geometry during your study of that concept? Explain.	To got vision of students about what do they think about activities, and their emotional feelings about this question.
Which one of the concrete materials was useful for you? Why?	To get information about which one of the materials is most useful for them and the reason for it.
Which one of the concrete materials do you like most? Why?	To get information about which one of the materials they like most and their reasons.
How do you feel while using concrete materials? Why?	To investigate the emotional feelings while using concrete materials and the reasons.
With which courses were you able to make a relation with geometry during performing activities with concrete materials?	To understand whether they make a relation with geometry and other courses. Moreover, it is expected that studentswould say the name of the courses.

G. INTERVIEW ANSWERS

A öğrencisi

Matematik seviyesi: İyi
Yanıt: çok güzel bir ders. Önceden sevmiyordum, şimdi daha çok seviyorum.
Yanıt1a: Öğretmen. Bana bu dersi siz sevdirdiniz.
Yanıt2: Geometri, açıölçer,cetvel ve problemler geliyor.
Yanıt3: Somut materyallerle işlediğimiz dersler çok güzeldi. Örneğin; simetri aynasını koyarak çizdiğimiz şekillerin simetrilerini görebiliyoruz. Geometri tahtasında çevre ve alan hesaplamaları yapabiliyoruz. Deftere çizmekten daha basit olduğu için daha çok keyif aldığımı söylemek isterim. Sonra açıölçeri açıları ölçmek için kullandık.
Yanıt4: Çok zorlandım. Hiçbirşey öğrenmediğimiz için açıları ölçmek, çevrelerini alanlarını hesaplamak çok daha zor oluyordu.
Yanıt5: çok basit geldi ve daha kolay çözdüm.
Yanıt6: Öncelikle materyal kullanarak dersi daha iyi anladığımı söyleyebilirim. Soyut olunca veya tahtaya çizilince hiçbirşey anlaşılmazken, somutlaştırınca herşey daha iyi anlaşılıyor.
Yanıt7: kesinlikle oldu. Bir kere soruları çözerken o etkinlikler aklıma geldi. Yani sorular bebek işi oldu.
Yanıt8: Açıölçer.çünkü çok basit ve kolay ölçüm yapılıyor. Böyle ölçünce daha basit oluyor. Mesela simetri aynası zordu.
Yanıt9: Geometri tahtası. Çünkü lastikleri takınca şekil oluşturmak güzel oluyor.
Yanıt10: Mutluluk hissettim. Çünkü, bir materyali herkesin kullanması güzel oluyor. Kendim kullanırken de çok eğlendim. Ayrıca dersi de daha çok sevmeye başladım.
Yanıt11: Fen bilgisi dersi ile kurduk. Fen dersinde çok alet olduğu için ona benzetebiliriz.

B öğrencisi
Matematik seviyesi: orta
Yanıt1: Benim aklıma Matematik deyince sayılar, dört işlem, problemler geliyor. Matematik bence günlük hayatımızda çok kullandığımız bir ders. Bu dersi okulda almamız çok iyi bir şey.
Yanıt2: Bankalarda, alışveriş merkezinde, faturalarda kullanıyoruz. Her yerde sayılar olduğu için Matematiği de her yerde kullanıyoruz.
Yanıt: materyal kullanarak işlediğimiz dersler bence daha eğlenceliydi. Deneyerek yaptığımız için daha çok aklımızda kaldı aslında. Daha iyi öğrendik, bizim için daha iyi oldu.
Yanıt: daha iyi çözmeye başladım. Çünkü,deneyerek yaptığımız için

unutmadım. Örneğin, geometri tahtasında üçgenler yaptık, çevrelerini vew alanlarını hesapladık. O tarz soruları daha iyi çözdüm. Sonra simetri aynası kullandık. Küpler kullanmıştık. Şekilde kaç tane küp olduğunu bulabilmeme yardımcı oldu.
Yanıt4: Yani çok daha zordu.
Yanıt5:Şimdi bakıyorum aynı sorular çok daha kolay geliyor. Soruları çözerken kendimi daha rahat hissettim.
Yanıt6: Deneyerek yaptığımız için diğer sorularda da söylediğim gibi problemleri çözmemi kolaylaştırdı.
Yanıt7: Daha önceden Matematiği bu kadar sevmiyordum. Tabi öğretmenimizin de sayesinde, hem etkinlikleri yaptırdı bize, böylece ben de çok sevmeye başladım. Etkinliklerde kullandığımız materyaller sayesinde konular daha çok aklımda kaldı.
Yanıt8: Geometri tahtalarını öğretmenim. Çünkü dikdörtgenin alanını, çevresini hesaplamamızı kolaylaştırdı.
Yanıt9: aslında hepsini. Öğretmenim,katlanabilir cetvel. Çünkü onunla işlediğimiz dersler daha eğlenceli geçti.
Yanıt10: Daha eğlenceli geçtiği için diğerlerine göre daha mutlu hissettim.
Yanıt11: Diğer derslerle bir ilişki kuramadım öğretmenim.

C öğrencisi

Matematik seviyesi: İyi
Yanıt1:Çok güzel bir ders. Ben bu sene çok sevdim. Benim için en eğlenceli derslerden biri.
Yanıt 2:Eğlence geliyor, siz geliyorsunuz, 4 işlem gelliyor. Çarpmanın nasıl yapıldığını merak ettiğim günler geliyor. Ev yaparken uzunluk ölçüyoruz. Alışveriş yaparken ondalık kesir kullanıyoruz. Manavdan falan birşey alırken yani kütle ölçüleri.
Yanıt 3:Çok eğlenceli oluyor. Bazen kullanamıyorum veya zor kullanıyorum ama sonuçta deneyerek öğrendik. Siz öğrettiniz. Hiç kaygılanmadım ama öğrenemem diye. hemen öğrenebileceğimden emindim çünkü çok eğlenceliydi.Somut materyallerle yapılan dersler, geometri problemlerini çözmenizi nasıl etkiledi? Açıklayınız.
Yanıt 4: Kolaylık sağladı. Mesela simetri doğrusunu çiziniz diyordu,simetri aynaları onu çizmemde yardımcı oldu bana .İlk karşılaştığımda sorular çok zor gelmişti.
Yanıt 5: Sonrasında yani materyal kullandıktan sonra çok kolaylaştı.
Yanıt 6: Mesela ben çevre konusunu yapamıyordum senenin başında ama materyallerle işlediğimiz derslerin sonunda daha iyi yapıyorum. Unutmadım, dün gibi aklımda.
Yanıt 7:Çok olumlu etkiledi. Mesela simetri aynasını kullandığımızda daha kolay simetriklerini bulduk veya kontrol ettik. Küpleri kullanarak şekillerdeki küp sayısını daha kolay sayabildim. Matematiğin daha eğlenceli bir ders olduğuna karar verdim ve aslında zor gorunen konuları bile dinlersem daha iyi yapabileceğime karar verdim. Aslında kendime güven geldi.

Yanıt 8: Birim küpleri, çünkü hem eğlenmeme sebep oldu hem de şekillerin kaç küpten oluştuğunu öğrenmemi çok kolaylaştırdı.
Yanıt 9: Simetri aynasını, çünkü aynanın rengi güzeldi. Ayrıca ayna mantığı hoşuma gitti. Karşısında simetriğini görünce şaşırdım, çok sevindim.
Yanıt 10: Sevindim. Materyal kullanabiliyoruz diye sevindim. Dersleri böyle işlediğimiz için sevindim. Onları kullanmak güzeldi.
Yanıt 11:Eş küpler ve örüntü blokları bana biraz resim dersini anımsattı renkli olduğu için.

D öğrencisi

Matematik seviyesi: orta
Soru 1: Matematik dersi ile ilgili neler düşünüyorsun? Neden?
Senenin başındayken Matematiğin bu sene zor olacağını düşünüyordum.komsularımdan falan biliyordum matematiğin giderek zorlaştığını. Ama daha sonra yani sizle Matematik derslerine başlayınca ve materyal kullanınca bu fikrim değişti.
Soru2: Matematik deyince aklına neler geliyor?
Sayıların ve mantığın birleştiği bir derstir. Mesela geometriden örnek vereyim; annem bana geometride çizim ile ilgili bir kitap almıştı. Kitapta çizimler vardı,beni çok etkilemişti.
Soru3a: Materyal kullanarak işlediğimiz dersler ile ilgili neler düşünüyorsun?
Bence somut materyalleri kullanmak dersi daha iyi anlamamızı sağladı. Mesela birim küplerle çalışmak veya simetri aynası gibi materyalleri kullandıktan sonra konuların akılda kalması daha iyi oldu. Mesela biz Sosyal Bilgiler dersinde bile "Geçmişi Öğreniyorum " konusunda bile biz genelde materyaller getirmeye çelışıyorduk, öğretmen bize resimler gösteriyordu ve biz daha iyi anlıyorduk. Çünkü materyalle çalışmak ve resim görmek insanın aklında kalıyor. Ayrıca dersler daha eğlenceli oldu tabiki. Yani mesela senin başında üçgenler hakkında çeşitkenar üçgen falan hiçbirşey bilmiyordum ve babamda senenin ortasında bana bir kitap almıştı. O kitaptan ileriye doğru bakıyordum ve üzülüyordum yapamıyorum diye. Ama şimdi bakıyorum da bütün konular aklımda.
Soru3b: Somut materyallerle yapılan dersler, geometri problemlerini çözmenizi nasıl etkiledi? Açıklayınız.
Geometri tahtalarında lastikleri takınca,işte şurası uzun burası daha kısa diye sorgulayınca problemleri daha iyi çözdüm. Dediğim gibi görsel materyaller insanın daha iyi aklında kalıyor.
Soru4: Somut materyalleri kullanmadan önce geometri soruları ile karşılaştığınızda neler hissettiniz?
Üçgenlerde çok takılmıştım ama çizime ilgim olduğu için bazılarında o kadar da zorlanmadım.
Soru5: Somut materyalleri kullandıktan sonra geometri soruları ile karşılaştığınızda neler hissettiniz?

Kesinlikle daha iyi yaptım. Hatam olduğunu da zannetmiyorum.
Soru6: Somut materyallerle anlatılan dersler, geometri konularını anlamanızı nasıl etkiledi? Açıklayınız.
Çok iyi etkiledi. Daha iyi anladım kesinlikle. Görseller falan insanın daha iyi aklında kalıyor.
Soru7:Geometri konularının işlenişi esnasındaki **etkinliklerin**, geometriyi anlamanıza etkisi oldu mu? Neden?
Çok zevkliydi. Özellikle etkinlikleri Matematik laboratuvarında yapmak çok keyifliydi. Yani genelde sınıfta işlediğimiz derslerden daha etkileyiciydi etkinlikler. Etkinliklerde kullandığımız materyaller etkileyiciydi benim için. Daha önceki yılllarda da giderdik ama bu yıl çok etkinlik yaptık, eğlendik.

Soru8: Kullandığınız materyallerden en çok hangisini yararlı buldunuz? Neden?
Bence birim küpler yani birim küpleri her zaman kullanabiliyorsun. Mesela simetri aynasından veya geometri tahtasından daha fazla günlük hayatta kullanıyoruz. Bir de katlanabilir cetvel. O da şekiller kullanırken daha eğlenceli yapıyordu dersi.
Soru9: Kullandığınız materyallerden en çok hangisini sevdiniz? Neden?
Katlanabilir cetveli en çok sevdim. Çünkü daha eğlenceli ve şirindi.
Soru10: Somut materyalleri kullanırken kendinizi nasıl hissettiniz? Neden?
Çok rahat ve mutlu hissettim. Çünkü eğlenceliydi.
Soru11: Etkinlikler esnasında geometri ile hangi dersler arasında, nasıl bir ilişki kurdunuz?
Resim dersi ile bir ilişki kurdum. Mesela küpler, üç boyutlu cisimler ve uzay bakışında. Mesela Görsel sanatlar öğretmenimiz küpün açılımlarını ve farklı yönlerden bakılınca nasıl çizileceğini göstermişti. Bir de günlük hayatta oyuncaklarda gördüm. Kardeşime dergiler alıyorduk. Onlardan birinde katlanabilir birşey çıktı. Üçgen prizma, küp falan yapıyorduk.

E öğrencisi

Matematik seviyesi: Orta
Soru 1: Matematik dersi ile ilgili neler düşünüyorsun? Neden?
Matematik dersini çok seviyorum. Eskiden Matematiği sevmiyordum, ama şimdi daha çok sevmeye başladım.
Soru2: Matematik deyince aklına neler geliyor?
Öğretmenim hayat geliyor. Çünkü, mesela pazara gittiğinde para var kilogram var. Sonra iş hayatında mesela seyyar satıcılar bize birşey satarken Matematikleri iyi olmak zorunda. Matematik insanın hayatında önemli bir yardımcıdır. O olmazsa hayat olmayabilirdi.
Soru3a: Materyal kullanarak işlediğimiz dersler ile ilgili neler düşünüyorsun?
Materyal kullanmak çok zevkli. Öncelerden açıları hiç sevmiyordum, açıları nasıl ölçeceğimi bilmiyordum. Sonra iletkiyi görünce ve

kullanmayı öğrenince ilgili konular çok zevkli oldu ve daha kolaylaştı.
Soru3b: Somut materyallerle yapılan dersler, geometri problemlerini çözmenizi nasıl etkiledi? Açıklayınız.
Ölçmeyi öğrendim, açıları daha iyi öğrendim. Böylece soruları daha iyi çözdüm. Simetri aynasını kullanarak bir şeklin simetriğini daha kolay çizdim. Böylece o konuyla ilgili soruları daha kolay çözdüm.
Soru4: Somut materyalleri kullanmadan önce geometri soruları ile karşılaştığınızda neler hissettiniz?
Üzüldüm, kaygılandım. Çünkü yapamayacağımı düşünüyordum.
Soru5: Somut materyalleri kullandıktan sonra geometri soruları ile karşılaştığınızda neler hissettiniz?
Kaygım gitti, onun yerine mutluluk geldi.
Soru6: Somut materyallerle anlatılan dersler, geometri konularını anlamanızı nasıl etkiledi? Açıklayınız.
Derse ilgim arttı.
Soru7:Geometri konularının işlenişi esnasındaki **etkinliklerin**, geometriyi anlamanıza etkisi oldu mu? Neden?
Etkinliklerle yapılan derslerde mutlu oldum, dersi daha çok sevdim ve konuları daha iyi anladım.
Soru8: Kullandığınız materyallerden en çok hangisini yararlı buldunuz? Neden?
Birim küpleri yararlı buldum. Şekillerde kullanılan küp sayısını bilemiyordum ama birim küplerle şekilleri yapınca kullanılan küp sayısını daha iyi sayabildim.
Soru9: Kullandığınız materyallerden en çok hangisini sevdiniz? Neden?
En çok iletkiyi sevdim. Ölçüm yapabilmek beni mutlu etti.
Soru10: Somut materyalleri kullanırken kendinizi nasıl hissettiniz? Neden?
Küçükken kullanmayı bilmediğim materyaller vardı. Mesela cetveli bile bilmiyordum. Bilmediğim için üzülüyordum. Ama bizim derslerimiz, materyal kullandığımız için daha eğlenceli oldu. Ayyrıca mutluluk hissettim, çünkü kolaylaştırdı Matematik derslerini. Materyaller olmasaydı ben Matematiği daha zor anlardım. Hayatıma bu materyaller geldi, matematiği daha iyi anlamaya başladım.
Soru11: Etkinlikler esnasında geometri ile hangi dersler arasında, nasıl bir ilişki kurdunuz?
Yok kuramadım öğretmenim.

F öğrencisi

Matematik seviyesi: Orta
Soru 1: Matematik dersi ile ilgili neler düşünüyorsun? Neden?
Matematik dersi sevdiğim bir ders. Sayılardan hoşlanırım çünkü sayılar hayatımızın her yerinde var.
Soru2: Matematik deyince aklına neler geliyor?
Matematik deyince sayılar ve problemler aklıma geliyor. Asansör

düğmelerinde sayılar var, evleri yaparken matematik kullanılıyor.
Soru3: Materyal kullanarak işlediğimiz dersler ile ilgili neler düşünüyorsun?
Bu seneki matematiğin en beğendiğim bölümüydü. Çünkü şekillerle birşey yapmayı severim.
Soru3b: Somut materyallerle yapılan dersler, geometri problemlerini çözmenizi nasıl etkiledi? Açıklayınız.
Yaptığımız örnekleri daha kolay hatırladım, aklımda çok iyi kaldı.
Soru4: Somut materyalleri kullanmadan önce geometri soruları ile karşılaştığınızda neler hissettiniz?
Yani sorular çok zor geldi. Hiçbirşeye ilk bakışta ön yargılı olmamak gerek.
Soru5: Somut materyalleri kullandıktan sonra geometri soruları ile karşılaştığınızda neler hissettiniz?
Daha çok örnekler gördüğüm için ve konuyu iyi öğrendiğim için daha rahattım.
Soru6: Somut materyallerle anlatılan dersler, geometri konularını anlamanızı nasıl etkiledi? Açıklayınız.
Kağıt üzerinde değil de 3 boyutlu materyallerle dersi yapmak daha iyi oluyor. Daha iyi öğreniyorum, çünkü gözümle örnekleri gördüğüm için.
Soru7:Geometri konularının işlenişi esnasındaki **etkinliklerin**, geometriyi anlamanıza etkisi oldu mu? Neden?
Kesinlikle oldu. Daha çok eğlendiğim için aklımda daha iyi kaldı.
Soru8: Kullandığınız materyallerden en çok hangisini yararlı buldunuz? Neden?
Pipetleri kullanmıştık birçok etkinlikte, onları yararlı buldum. Onlarla kare ,üçgen, dikdörtgen yapmak daha kolay oldu.
Soru9: Kullandığınız materyallerden en çok hangisini sevdiniz? Neden?
En çok geometri tahtalarını sevdim. Bir de birim küpleri kullanarak izometrik kağıtlarının üzerine 3 boyutlu çizim yapmıştık, onları çok sevdim.
Soru10: Somut materyalleri kullanırken kendinizi nasıl hissettiniz? Neden?
İlk başlarda biraz endişeliydim. Ama sonradan ilk başladığım gün akşam eve gidince annemlere söyledim onlar da endişelenmene gerek yok dediler . ben de okula rahat bir şekilde geldim. Sonra kullanmaya başlayınca rahatladım. Dediğim gibi, materyallerle çalışmayı sevdiğim için rahat hissettim.
Soru11: Etkinlikler esnasında geometri ile hangi dersler arasında, nasıl bir ilişki kurdunuz?
Resim dersiyle ilişki kurabildim.

G öğrencisi

Matematik seviyesi: iyi
Soru 1: Matematik dersi ile ilgili neler düşünüyorsun? Neden?
Bence matematik en iyi derslerden biri. Çok güzel bir ders, çok sevdiğim bir ders. Çünkü bu derste çok güzel materyaller kullanıyoruz. Eğleniyorum aynı zamanda öğreniyorum.

Soru2: Matematik deyince aklına neler geliyor?
Sayılar, dört işlem, birim küpler, bütün matematik malzemeleri. günlük hayatımızda, alışveriş yaparken kullanıyoruz. Örneğin koltuk alırken kaç metre olduğuna bakılır, kaç para ödeyeceğimizi matematikle hesaplarız.
Soru3: Materyal kullanarak işlediğimiz dersler ile ilgili neler düşünüyorsun?
Çok eğlenceli derslerdi. Hem eğlendim, hem öğrendim. Milyonlarca şey yaptık. Küpleri üst üste getirerek gördüğümüz şekilleri çizmiştik. Matematiğin daha eğlenceli olduğunu anladım. Geçen sen matematiği ne kadar çok sevsem de, derslerde genelde uyuyakalıyordum, materyal kullandığım için daha aktif olabildim derslerde.
Soru3b: Somut materyallerle yapılan dersler, geometri problemlerini çözmenizi nasıl etkiledi? Açıklayınız.
Eğlendiğimden daha çabuk öğrendim. Konuları daha iyi kavradım. Böylece soruları daha kolay çözdüm.
Soru4: Somut materyalleri kullanmadan önce geometri soruları ile karşılaştığınızda neler hissettiniz?
Hiç bilmediğim konular vardı açı ölçme gibi, nasıl ölçüldüğünü bilmememe rağmen yapmak için yapmıştım.
Soru5: Somut materyalleri kullandıktan sonra geometri soruları ile karşılaştığınızda neler hissettiniz?
Çok daha kolay olduğunu anladım. Kare ve dikdörtgenin alanlarını hiç hesaplayamıyordum eskiden ama öğrendikten sonra tabi sorular da kolay geldi.
Soru6: Somut materyallerle anlatılan dersler, geometri konularını anlamanızı nasıl etkiledi? Açıklayınız.
3 boyutlu materyaller kullandığımızda, elimizde tutup çevirebildiğimizde , kaç birim küp olduğunu daha iyi saydım. Örneğin, geometri tahtasıyla yaptığımız kare ve dikdörtgenin alan ve çevre hesaplamaları aklımda daha iyi kaldığı için ilgili soruları daha kolay çözdüm.
Soru7:Geometri konularının işlenişi esnasındaki **etkinliklerin**, geometriyi anlamanıza etkisi oldu mu? Neden?
Evet. **Çok eğlendim ve daha iyi öğrendim.**
Soru8: Kullandığınız materyallerden en çok hangisini yararlı buldunuz? Neden?
Birim küpler , çünkü birim küpler 3 boyutluydu, biz izometrik kağıtta 2 boyutlu gördükten sonra küpleri elimize alarak şekilleri oluşturabildik. Bazen kitapta gördüğümüz 2 boyutlu şekillerde arka taraftaki küpleri göremiyorduk ama bizim küplerle yapınca kolay oldu, daha kolay saydık.
Soru9: Kullandığınız materyallerden en çok hangisini sevdiniz? Neden?
Simetri aynasını sevdim. Çünkü normal bir ayna 2 taraflı görünteleyemez. Böyle bir ayna olması çok şaşırtıcı geldi bana.
Soru10: Somut materyalleri kullanırken kendinizi nasıl hissettiniz? Neden?
Çok mutlu oldum çünkü milyonlarca iş yapmayı öğrendim. Matematiğin

bu kadar çok yerde kullanıldığını bilmiyordum, öğrendikçe mutlu oldum.

Soru11: Etkinlikler esnasında geometri ile hangi dersler arasında, nasıl bir ilişki kurdunuz?

Fen ve Teknoloji dersiyle kurabiliriz.bazı şeylerin şekillerle hesaplandığını öğrendim, onları anlamamda bana yardımcı olacağını düşünüyorum.

H öğrencisi

Matematik seviyesi: orta

Soru 1: Matematik dersi ile ilgili neler düşünüyorsun? Neden?

Bence eğlenceli bir ders. Çok mantıkla haraket ettiğimiz bir ders. Matematikte en çok geometriyi seviyorum. Çünkü ben resim çizmeyi seviyorum, geometride çok resim çizmeli oluyor, o nedenle çok seviyorum.

Soru2: Matematik deyince aklına neler geliyor?

Sayılar geliyor aklıma, simetri geliyor. Alışveriş merkezinde hesaplama yaparken kullanıyoruz, inşaatta kullanıyoruz.

Soru3: Materyal kullanarak işlediğimiz dersler ile ilgili neler düşünüyorsun?

Materyallerle olunca eğlenceli oluyor. 3 boyutlu maketleri kullanmak çok çok eğlenceliydi.

Soru3b: Somut materyallerle yapılan dersler, geometri problemlerini çözmenizi nasıl etkiledi? Açıklayınız.

Konu ile ilgili problemler geldiğinde 3 boyutlu düşünmemi sağladı. Çözerken şekil çizmemi kolaylaştırdı.

Soru4: Somut materyalleri kullanmadan önce geometri soruları ile karşılaştığınızda neler hissettiniz?

O zaman daha fazla yanlış yapmışımdır.

Soru5: Somut materyalleri kullandıktan sonra geometri soruları ile karşılaştığınızda neler hissettiniz?

Materyal kullandıktan sonra çizmeye başladım o zaman da kolay olmaya başladı.

Soru6: Somut materyallerle anlatılan dersler, geometri konularını anlamanızı nasıl etkiledi? Açıklayınız.

Örneğin birim küplerde, yapıyı oluşturduğumuzda arka taraftaki küpleri daha rahat görebiliyoruz. Geometri tahtaları ile geometrik şekilleri öğrenmek daha kolay oluyor, çünkü lastik kullanarak şekillerin kenarlarını, köşelerini daha kolay görebiliyoruz. Öğreneceklerimizi somutlaştırdığı için daha iyi öğreniyoruz.

Soru7:Geometri konularının işlenişi esnasındaki **etkinliklerin**, geometriyi anlamanıza etkisi oldu mu? Neden?

Etkinliklerle matematiğin daha eğlenceli olduğunu düşünmeye başladım. İlk başta söylediğim gibi benim resim çizmeyi filan seviyorum,etkinlikleri de resim gibi, 3 boyutlu yaptık çok eğlenceli oldu.

Soru8: Kullandığınız materyallerden en çok hangisini yararlı buldunuz? Neden?
En çok örüntü bloklarını yararlı buldum. Çünkü onlar daha böyle 3 boyutlu olunca daha eğlenceli oldu.
Soru9: Kullandığınız materyallerden en çok hangisini sevdiniz? Neden?
Ben en çok izmometrik kağıtta verilen çizimleri birim küplerle oluşturmayı sevdim.yani birim küpleri.
Soru10: Somut materyalleri kullanırken kendinizi nasıl hissettiniz? Neden?
Bence bu zamana kadarki en güzel Matematik dersleriydi. Daha önce hiç bu kadar mataryel kullanmamıştık. Materyal kullanmak çok eğlenceli ,maket yapmak gibi.
Soru11: Etkinlikler esnasında geometri ile hangi dersler arasında, nasıl bir ilişki kurdunuz?
Sosyal bilgiler dersinde şekillerle işimiz oluyor onlarla olabiliyor. Ya da Türkçe dersinde imler var, bu imler geometrik şekil gibi. Mesela nokta yuvarlak şeklinde, ünlemin de üstü dikdörtgen şeklinde.

I öğrencisi

Matematik seviyesi: iyi
Soru 1: Matematik dersi ile ilgili neler düşünüyorsun? Neden?
Çok eğlenerek yapıyoruz, eğlenerek öğreniyoruz. Öğretmenler hep güleryüzlü. Çok iyi bir ders.
Soru2: Matematik deyince aklına neler geliyor?
Aklıma rakamlar geliyor, sonra şekillerle birlikte geometri geliyor. Aklıma gelen tüm meslekler için gerekli bir ders Matematik. Örneğin bir futbolcunun bile topu ne kadar yüksekliğe atacağını hesaplaması gerekiyor.
Soru3: Materyal kullanarak işlediğimiz dersler ile ilgili neler düşünüyorsun?
Daha çok eğleniyoruz. Mataryeller olmasaydı çok sıkıcı bir ders olurdu. Böyle daha çok sevdiriyorsunuz bize Matematiği. Kendimiz modeller yapıyoruz, çok keyifli oluyor.
Soru3b: Somut materyallerle yapılan dersler, geometri problemlerini çözmenizi nasıl etkiledi? Açıklayınız.
Hepsinde bir kolaylık sağladı. Mesela simetri aynasını tuttuğunuzda şeklin simetriğini gösteriyor. Bu da hem öğrenmeni hem anlamanı kolaylaştırıyor. Katlanabilir metre ile açılarla ilgili problemleri çözmemizi kolaylaştırdı.
Soru4: Somut materyalleri kullanmadan önce geometri soruları ile karşılaştığınızda neler hissettiniz?
Heyecan hissettim.
Soru5: Somut materyalleri kullandıktan sonra geometri soruları ile karşılaştığınızda neler hissettiniz?
O zaman çok rahattım. Hepsini işledik hepsini öğrendik, soruları daha rahat yanıtladım.

Soru6: Somut materyallerle anlatılan dersler, geometri konularını anlamanızı nasıl etkiledi? Açıklayınız.
Önceleri matematiği çok sıkıcı bir ders olarak düşünüyordum. Ama materyaller kullanınca daha da çok sevdiğim matematiği ve geometri konularını daha iyi öğrendim.
Soru7:Geometri konularının işlenişi esnasındaki **etkinliklerin**, geometriyi anlamanıza etkisi oldu mu? Neden?
Çok eğlendiğim için çok öğrendim. Soruları daha kolay çözdüm.
Soru8: Kullandığınız materyallerden en çok hangisini yararlı buldunuz? Neden?
En çok simetri aynasını yararlı buldum resmin kenarına tutunca o sana resmin simetriğini gösteriyordu ve çizimi kolaylaştırıyordu.
Soru9: Kullandığınız materyallerden en çok hangisini sevdiniz? Neden?
En çok birim küpleri sevdim. Öğretmenim en çok onunla eğlendim. Onlarla modeller yaparken çok eğlendiğim için daha çok sevdim.
Soru10: Somut materyalleri kullanırken kendinizi nasıl hissettiniz? Neden?
Çok mutlu oldum. En sevdiğim derslerden biri oldu böylece Matematik. Çok eğleniyorum öğretmenim Matematikte.
Soru11: Etkinlikler esnasında geometri ile hangi dersler arasında, nasıl bir ilişki kurdunuz?
Öğretmenim ilişki kuramadım aslında. Resim dersinde modeller yapmıştık belki onla ilişki kurabiliriz.

K öğrencisi

Matematik seviyesi: iyi
Soru 1: Matematik dersi ile ilgili neler düşünüyorsun? Neden?
Dersler eğlenceli geçiyor çünkü öğretmen materyallerle oyun oynatıyor.
Soru2: Matematik deyince aklına neler geliyor?
Sayılar, problemler geliyor. Kendimizin 3 boyutlu olması geliyor aklıma bir de simetri geliyor.
Soru3: Materyal kullanarak işlediğimiz dersler ile ilgili neler düşünüyorsun?
Aslında gözle değil de yaparak daha iyi öğrendiğimiz için daha iyi oldu bizim için. Konuları daha
iyi öğrendim.
Soru3b: Somut materyallerle yapılan dersler, geometri problemlerini çözmenizi nasıl etkiledi? Açıklayınız.
Daha iyi anladığım için daha zevkli ve daha eğlenerek çözdüm. Duyarak değil de yaparak öğrendiğim için soruları daha kolay yanıtladım.
Soru4: Somut materyalleri kullanmadan önce geometri soruları ile karşılaştığınızda neler hissettiniz?
O zaman zorlanmıştım. Çünkü konuları öğrenmemiştim.
Soru5: Somut materyalleri kullandıktan sonra geometri soruları ile karşılaştığınızda neler hissettiniz?
Materyal kullanarak konuları öğrendikten sonra daha kolay çözdüm. Öğrenince tabiki daha kolaylaştı.

Soru6: Somut materyallerle anlatılan dersler, geometri konularını anlamanızı nasıl etkiledi? Açıklayınız.
Daha zevkli dinledim. Mesela küplerde ve süsleme yaparken daha iyi oldu.
Soru7:Geometri konularının işlenişi esnasındaki **etkinliklerin**, geometriyi anlamanıza etkisi oldu mu? Neden?
Etkinliklerle daha iyi anladım.yaparak öğrendiğim için daha çok zevkliydi.
Soru8: Kullandığınız materyallerden en çok hangisini yararlı buldunuz? Neden?
Küpleri, çünkü farklı açılardan baktığımızda daha kolay sayabildik. Mesela küpü normal koyuyorduk, b farklı yerlerden bakınca farklı görüyorduk.
Soru9: Kullandığınız materyallerden en çok hangisini sevdiniz? Neden?
En çok süslemeleri sevdim. Mesela biz etkinlikler esnasında çiçek yapmıştık, o esnada boşluk bırakmamaya dikkat ettik. Simetrik yaptığımızda göze daha iyi göründü.
Soru10: Somut materyalleri kullanırken kendinizi nasıl hissettiniz? Neden?
Eğlendim.
Soru11: Etkinlikler esnasında geometri ile hangi dersler arasında, nasıl bir ilişki kurdunuz?

Yani başka derslerle ilişki kuramadım.

L öğrencisi
Matematik seviyesi: zayıf
Soru 1: Matematik dersi ile ilgili neler düşünüyorsun? Neden?
İlk başka matematiği fazla sevmiyordum. Ama öğreetmenlerim bana matematiği sevdirdi.
Soru2: Matematik deyince aklına neler geliyor?
Geometri, dört işlem geliyor. Bazı malzemelerle ölçüm yapmak geliyor. İletkiyle bazı şeyleri ölçmek geliyor.
Soru3: Materyal kullanarak işlediğimiz dersler ile ilgili neler düşünüyorsun?
Materyalleri kullanınca daha zevkli oluyor. Konuları daha ayrıntılı anlayabildim.
Soru3b: Somut materyallerle yapılan dersler, geometri problemlerini çözmenizi nasıl etkiledi? Açıklayınız.
Daha kısa çözümler buldum. Mesela alan veya çevreyi hesaplarken geometri tahtası kullanmıştık.
Soru4: Somut materyalleri kullanmadan önce geometri soruları ile karşılaştığınızda neler hissettiniz?
Biraz dehşete düştüm yapamadım. Çok zor geldi.
Soru5: Somut materyalleri kullandıktan sonra geometri soruları ile karşılaştığınızda neler hissettiniz?
O zaman daha iyi yapabileceğimi ve tedirgin olmamam gerektiğini hissettim. Şekillerle daha iyi yapabileceğimi düşündüm.

Soru6: Somut materyallerle anlatılan dersler, geometri konularını anlamanızı nasıl etkiledi? Açıklayınız.
Bence matematik derslerinde materyaller daha fazla kullanılmalı.
Soru7:Geometri konularının işlenişi esnasındaki **etkinliklerin**, geometriyi anlamanıza etkisi oldu mu? Neden? **Şekil kullanmadan ben geometriyi anlayamıyordum ama şekillere daha çok ağırlık verince daha iyi yapabiliyorum.**
Soru8: Kullandığınız materyallerden en çok hangisini yararlı buldunuz? Neden?
Bence birim küpler daha yararlıydı.
Soru9: Kullandığınız materyallerden en çok hangisini sevdiniz? Neden?
Geometri tahtasını çünkü onun üstünde saymakta daha eğlenceli.
Soru10: Somut materyalleri kullanırken kendinizi nasıl hissettiniz? Neden?
Çok zevkliydi malzemeler biraz oyun gibi geliyor. Kendime daha çok güvendim.
Soru11: Etkinlikler esnasında geometri ile hangi dersler arasında, nasıl bir ilişki kurdunuz?
Resim dersine benzettim. Çünkü resimlerde de birim küpler filan olabiliyor.

H. SAMPLE WORKSHEETS

Aşağıda verilen harflerin simetri eksenlerini <u>cetvel kullanarak</u> çiziniz. Simetri ekseni

Öğrencinin Adı, Soyadı: **Sınıfı, Numarası:** **Konu: Simetri**	**MAYIS 2009**

olmayan harfleri daire içine alınız.

A B C D E F

I J K L M N

R S T U V Y

G H O P Z

İ. OBSERVATION SHEET

The classrooms' physical properties	#Yes	#Partially	#No
Is the lightning enough?	5	0	0
Is there enough space to conduct demonstrations?	5	0	0
Teacher's Characteristics			
The teacher has a friendly relationship.	5	0	0
The teacher enforces students to join the lesson.	5	0	0
The teacher gives opportunity to the students to join the lesson.	5	0	0
The teacher is respectful to students' ideas	5	0	0
Student's Characteristics			
Are students eager to learn in the lessons?	5	0	0
Are students involved in the lessons?	5	0	0
Method Related Characteristics			
Is the method conducted in class student centered?	5	0	0
Does the teacher ask what students know initially at the beginning of the lesson?	5	0	0
Does the teacher ask students what they couldn't learn about the topic?	5	0	0
Are concrete materials used?	5	0	0
Are concrete materials successful tools for teaching the topic?	5	0	0
Are daily life examples presented related to subject?	5	0	0
Are the demonstrations performed related to subject?	4	1	0
Are there classroom discussions?	4	1	0
Does the teacher stress on the concepts?	5	0	0
Does the teacher enforce students to think critically?	5	0	0
Are the students warned about what to do for the next lesson?	5	0	0